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KUSKOKWIM RIVER SONAR PROJECT
ABUNDANCE ESTIMATES OF SALMON SPECIES, 1994

by

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## ABSTRACT

The Kuskokwim River sonar project provided estimates of salmon species passage from 5 June through 15 August, 1994. Three transducers were used to collect hydroacoustic data, including a transducer deployed approximately 40 m from shore on 17 June to allow more complete hydroacoustic sampling along the complex bottom on the right bank. Side-looking sonar sampled 280 m of 350 m between the transducers on right and left banks. The remaining 70 m was sampled by down-looking sonar to estimate total passage. Total passage estimates were: 110,445 chinook *Oncorhynchus tshawytscha*, 307,319 sockeye *O. nerka*, 779,037 chum *O. keta*, 405,903 coho *O. kisutch*, and 40,022 pink salmon *O. gorbuscha*. Total passage estimates of non-salmon species included 124,097 whitefish (broad *Coregonus nasus* and humpback *C. clupeaformis*), 184,066 least cisco *C. sardinella*, and 10,467 fish of other species. Bethel test fishery CPUE data generally corroborated sonar passage estimates qualitatively, with the exception of coho salmon. However, correlation analyses revealed the opposite pattern - poor relationships between daily CPUE and daily sonar passage estimates for all managed salmon species except coho salmon . Correlation analyses also indicated poor relationships between sonar passage and CPUE for all species within strata. Set gillnet CPUE and right bank nearshore sonar passage showed the poorest relationship of all strata. Deep drift gillnets (8.5 m) were adopted as a means of more adequately sampling chum salmon not susceptible to capture in standard depth (4.3 m) gillnets. Permanent sandbag anchors deployed offshore helped set gillnets to fish effectively.


KEY WORDS: salmon, hydroacoustic, Kuskokwim River, escapement

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## INTRODUCTION

Kuskokwim River salmon stocks are harvested for both commercial and subsistence use. Commercial fishing harvests from 1989-1993 averaged approximately 1,260,000 combined chinook *Oncorhynchus tshawytscha*, sockeye *O. nerka*, coho *O. kisutch*, and chum salmon *O. keta*. Revenues from in-river harvests during the same period averaged nearly $3.5 million (Francisco et al. 1994, 1993, 1992, 1991, 1990). In addition, an estimated average of approximately 230,000 salmon were harvested annually for subsistence purposes. Commercial fishing occurs through 375 km (233 mi) of the river, with the most intensive commercial fishery located in the area within 220 km (137 mi) of the river's mouth. Although all five species of Pacific salmon occur in the river, chum and coho salmon are the primary species targeted in the commercial fishery. Subsistence fishing occurs throughout the river's 1,498 km (931 mi) length, and primarily targets chinook and chum salmon. Salmon harvest by sport fishers remains insignificant throughout most of the Kuskokwim River drainage.

Management of the fishery resource requires timely estimates of run strength and escapement. Visual assessment of migrating salmon abundance in the Kuskokwim River is precluded by turbid water, and extensively braided, relatively deep river channels. Historically, this commercial salmon fishery has been primarily managed using catch per unit effort (CPUE) data from gillnet test fisheries and the commercial fishery. However, CPUE data has limited value as an abundance index , because it is confounded by variable catchability of fish. Managers have also used escapement assessments from upriver spawning tributaries, but by the time reliable assessments of escapement can be made, a large portion of the stocks have passed through the primary commercial and subsistence fishing areas in the river's mainstem. In order to improve managers' ability to assess run strength, the Department began to develop a sonar project on the Kuskokwim River near Bethel in 1988.

The purpose of the Kuskokwim River sonar project is to provide daily passage estimates of chinook, sockeye, chum and coho salmon at Bethel. To do this, species proportions estimates from the Bethel test fishery project are applied to daily passage estimates of all fish species generated from hydroacoustic data. Daily estimates of passage were used for the first time in 1994 to manage salmon stocks on the Kuskokwim River.

The sonar project began with a three year feasibility phase (1988-1990), and has continued to develop since that time. In 1991, the Bethel test fishery project was restructured to provide data for estimation of species proportions. In 1992, transducers were deployed on both banks and radiotelemetry equipment was developed by the University of Alaska Fairbanks (UAF) Geophysical Institute to remotely transmit left bank (facing downstream) data to the right bank control center. Transducers operating at a resonant frequency of 120 kHz were also tested at this time in an effort to avoid signal attenuation experienced with the 420 kHz frequency previously used on the project (Vaught et al. 1995). Both of these developments were included in routine project operation in 1993. In 1994, the species apportionment process was modified so that fish passage in discrete range strata were apportioned to species by test fishery data collected at stations within those strata, rather than apportioning fish passage over the entire river with average species proportions from all stations across the river's width. The purpose of the stratified apportionment was to increase accuracy of species passage estimates.

The site used for hydroacoustic sampling since project inception is located at river km 130 (mi 79), approximately 5 km (3 mi) upstream from Bethel (Figure 1). This site was selected because the best available combination of physical characteristics favorable to hydroacoustic sampling were found there. The river flows in a single channel, although four relatively small sloughs do bypass the site. The river is approximately 475 m wide at high tide. The bottom at the site has a relatively uniform gradient, with a maximum depth of approximately 12 m. The bottom slope on the right bank is quite steep, out to approximately 40 m from shore. From that point, a shallower grade extends to the thalweg of the river. From the thalweg, the left bank rises in a uniform gradient to the edge of a mud bar. The mud bar extends approximately 125 m from the left bank into the river channel, leaving approximately 350 m of river width at all tide stages. Water flow is affected by tidal fluctuation and flow direction is occasionally reversed on particularly high tides. The only known salmon spawning stream that is downstream from the site is the Eek River, located at approximately river km 19 (mi 12).

## METHODS

### *Hydroacoustic Sampling*

#### Equipment and Procedures

*Equipment.* Separate sonar systems were used to sample the nearshore and offshore zones of the right bank. Equipment for the nearshore sonar system on 1 June included a Biosonics[2] model 105 echosounder, an Acoustic Transducer Inc. (ATI) 4° single-beam transducer, 152.4 m (500 ft) of Belden 8412 transducer cable, a Remote Ocean Systems (ROS) PT-25 remote pan and tilt unit, 152.4 m of Belden 9934 pan and tilt cable, and a Biosonics model 111 thermal chart recorder. The offshore sonar system as deployed on 1 June included a Biosonics model 102 echosounder, an International Transducer Corporation (ITC) model 5398 elliptical transducer configured dual-beam with nominal beam width of 2.0° x 4.7° narrow beam, 4.1° x 9.5° wide beam, two 152.4 m Belden 8412 transducer cables, a ROS PT-25 remote pan and tilt unit, 152.4 m of Belden 9934 pan and tilt cable, and a Biosonics model 111 thermal chart recorder. Support electronics on the right bank included a Biosonics model 151 multiplexer-equalizer, a Nicolet model 310 digital storage oscilloscope, a Biosonics model 181 Echo Signal Processor (ESP) card installed in a Compaq Deskpro 386 microcomputer, a Compaq 8088 microcomputer, a ROS

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[2]Use of vendor names does not constitute endorsement.

model PTC-1 remote pan and tilt controller with digital position feedback, and UAF-developed radio telemetry equipment.

On 17 June, the right bank offshore sonar system was relocated farther offshore and the sonar system restructured to a Biosonics model 102 echosounder, an ITC model 5398 transducer configured dual-beam with nominal beam angles of 4.5° x 9.3° narrow beam, 13.5° x 22.0° wide beam, 304.8 m (1000 ft) of Alpha 6032C transducer cable, 304.8 m of Belden 9934 pan and tilt cable, and a ROS PT-25 remote pan and tilt unit. At this time, the former right bank offshore sonar system was put in place to sample the right bank nearshore.

The left bank sonar system consisted of a Biosonics model 102 echosounder, an ITC model 5398 elliptical transducer configured dual-beam with nominal beam angles of 4.0° x 9.1° narrow beam, 13.1° x 21.4° wide beam, 304.8 m (1000 ft) of Belden 8412 transducer cable, a ROS model PT-25 remote pan and tilt unit, 304.8 m of Belden 9934 pan and tilt cable, and the radiotelemetry equipment. Left bank sonar data were displayed on a Biosonics model 111 thermal chart recorder in the right bank control tent. Radiotelemetry equipment functioned to telemeter data from the left bank to the right bank control system, remotely start and stop the left bank generator, and act as a pan and tilt control unit for the left bank.

Both bank's sonar systems and support electronics were powered by Honda EM-3500 generators. Transducers were attached to pan and tilt units and the transducer/pan and tilt assemblies were mounted on steel or aluminum tripods for deployment. Pan and tilt units allowed transducers to be remotely rotated through pan and tilt axes from the right bank control center. The electronic equipment on each bank was housed in a 2.4 m x 3.0 m (8 ft x 10 ft) wall tent on a wood platform.

*Sampling Design*. Two transducers were deployed on the right bank, one each for sampling the nearshore (0-40 m) and offshore (40-180 m) zones. Both right bank transducers were originally deployed on 1 June in a roughly side-by-side design, approximately 5-8 m offshore. The left bank transducer was deployed on the offshore side of the mud bar, such that the river channel distance between transducers was approximately 350 m. Sampling range on the left bank was 75 m. Single-beam sampling was continuous on both banks.

On 17 June, several changes were made to the project's sample design. The right bank offshore transducer was relocated approximately 40 m offshore, where the shallow gradient of the right bank bottom slope began (Figure 2). This allowed more complete ensonification along the bottom throughout the right bank sampling range. A completely new system was deployed to sample the offshore zone (see *Equipment*). The right bank nearshore maximum sampling range was extended to ensonify from 0 to 50 m, and the offshore sampling range was extended to ensonify from 50 to 190 m. The right bank nearshore maximum sampling range actually extended 20 m beyond the position of the offshore transducer to maximize the cross sectional area sampled where the offshore transducer's beam was small. This also prevented collection of dual-beam data within the Fresnel zone of the offshore transducer. Left bank maximum sampling range was simultaneously extended from 75 m to 90 m. The sampling schedule was also changed from a continuous design to sampling alternate 1-h periods on each bank because of cross-talk between right and left bank transducers.

A single fisheries technician operated and monitored equipment at the control center. Crew members rotated through shifts of 0000-0800, 0800-1600, and 1600-2400 hours. During those shifts, fish traces were tallied from charts and summarized by 15-minute subsample and range sector. Range sectors were 10 m wide on the right bank nearshore and left bank, and 20 m wide on the right bank offshore. Crew members recorded fish counts on data forms and subsequently entered these data into Quattro Pro 1.0 electronic spreadsheets. Data forms and electronic spreadsheet files were transported to the project field office in Bethel each day for estimation of total daily passage. In single-beam operation, chart recorder output constituted the only record of detected echoes and fish passage. Dual-beam data were collected in 1-h periods, alternating between right and left bank, starting 3 July.

To determine the proportion of fish passing beyond the range of side-looking sonar beams (190-260 m, referenced from the right bank), down-looking sonar transects were performed with a Lowrance X-15 graphing fathometer. Transects were made across the full width of the river. They began approximately at the right-bank nearshore transducer and proceeded on a straight course across the river. Boat speed and fathometer paper speed were held constant so that chart recordings would have a relatively consistent distance scale. The fathometer's gain (sensitivity) was held constant at a setting of 3 on a scale of 1 to 9. Six replicate transects were completed three times each day at approximately 0600, 1200, and 1800 hours, although transects were not performed during commercial fishing periods. Transect chart recordings were digitized using a Summagraphics SummaSketch II Professional digitizing tablet with ADF&G developed software (KDIG 1.0). Fish were located on an x:y coordinate grid where x = distance, and y = depth. Maximum depth was taken as the average maximum depth for each set of six transects. Maximum distance was defined as 350 m, the distance between right and left bank transducers. On the X axis, zero corresponded to the right bank, 350 m to the left bank.

To gain an accurate bottom profile on the right bank, depth measurements were needed at known distances from shore. To accomplish this, a 100 m tape was suspended from shore to an open skiff with a Lowrance X-15 fathometer on board. As the skiff was driven straight offshore, the distance on the 100 m tape was called off in 5-m increments and the depth recorded on the fathometer to a distance of 85 m from shore using the 'mark' function (a vertical line is generated at that point on the chart paper). Depths were later digitized in the same method described for transects used to detect fish.

*System Parameters.* Echosounder settings and chart recorder voltage thresholds were varied on both banks between 5 and 17 June in attempts to find the lowest threshold that could be maintained. Voltage thresholds corresponded to target strengths of -48 to -42 decibel-volts (dBv) on the maximum response axis (MRA). The lowest threshold attainable with the right bank offshore system deployed on 17 June was -40 dBv. Voltage thresholds for the right bank nearshore and left bank systems were set at -40 dBv at this time to match the right bank offshore threshold (Table 1). At the beam's half-power point (-6dBv), the smallest fish detectable on chart recorders had a target strength of -34 dBv.

*System Calibration.* Sonar systems used on both banks were calibrated in March, 1994 by Precision Acoustic Systems (PAS), Seattle, WA. Target strength data from a 38.1 mm diameter tungsten carbide sphere were collected through the ice on 14 April at Eklutna Lake to verify PAS calibration results. Additionally, target strength data from a 38.1 mm stainless steel sphere were collected in-season for verification of system stability as follows: for the right bank nearshore system on 12 July, for the left bank system on 20 July, and for the right bank offshore system on 20 June and 4 August. Tungsten carbide and stainless steel spheres were suspended from equatorial net-bags made of monofilament line. For the exercise at Eklutna Lake, the sphere and net bag were suspended by monofilament line attached to a lightweight fishing rod. For in-season data collection, the sphere and net-bag were suspended by monofilament line from the end of a pole in an anchored boat. Once the sphere was detected in the sonar beam, the transducer was aimed from the control center until the sphere was approximately on the MRA. All standard target data were analyzed in-season.

Analytical Methods

*Estimates of Daily Total Fish Passage.* Total fish passage estimates were reported according to four strata defined by range from the right bank: stratum one (0-40 m), stratum two (40-190 m), stratum three (190-260 m- the unensonified zone), and stratum four (260-350 m). Before 18 June, these four strata were defined as 0-40 m, 40-180 m, 180-275 m, and 275-350 m. Daily total fish passage in stratum $s$ ($\hat{Y}_{ds}$) within the ensonified zone was estimated as

$$\hat{Y}_{ds} = \frac{\sum_{c} \sum_{q=1}^{n_q} y_{dscq}}{(n_q)/96} , \tag{1}$$

where s = 1,2 and 4, and $y_{dscq}$ = estimated passage of fish on date $d$, in stratum $s$, in range sector $c$, in 15-minute subsample $q$, and $n_q$ = number of subsamples in day's total sampling.

Daily total fish passage in stratum three, the unensonified zone was estimated by

$$\hat{Y}_{ud} = \hat{Y}_{ed}\left(\frac{TR_t}{TR_e} - 1\right) \tag{2}$$

where $\hat{Y}_{ed}$ = passage in the ensonified zone, summed across strata, $TR_e$ = number of fish detected in transects in the ensonified zone, and $TR_t$ = number of fish detected in transects for the entire river cross section. In estimating passage in the unensonified zone, fish detected within 50 m of either bank by both down-looking and side-looking sonar were not considered. Thus, $\hat{Y}_{ed}$ in (2) represents the number of fish in a day estimated to have passed in the 50-190 m and 260-300 m zones, $TR_e$ represents fish detected with down-looking sonar in the same zones, and $TR_t$ represents fish detected by down-looking sonar from 50-300 m.

*Transect Data.* Because the fathometer's sonar beam expanded in diameter with depth, probability of fish detection was a function of depth. To correct detected distribution of fish to reflect equal probability of detection with depth, individual fish were expanded by

$$C = \frac{d_m}{d_t} . \tag{3}$$

where $d_m$ = maximum depth (ft), and $d_t$ = depth of target. Fish less than 1.5 m (5 ft) from the surface were expanded for depth as if they had been detected at 1.5 m. This limited the influence that near-surface fish had on the number of transect fish estimated in the ensonified and unensonified zones, after expansion for probability of detection with depth.

*Missing Data.* Three or four 15-min subsamples were sacrificed each day for equipment maintenance such as generator refueling and oil changes. Equipment malfunction also caused occasional sampling down-time.

After an aiming error on the right bank offshore transducer was discovered and corrected on 15 June, it became apparent that bottom oriented fish could not be sampled through the entire offshore sampling range with a transducer deployed near shore. Thus the right bank offshore passage for the period 5 June to 17 June was estimated using the ratio of right bank offshore/left bank passage for the period 18 June to 21 June. Passage in the right bank nearshore zone was estimated similarly for 9 August and 10 August, when the transducer tripod tipped over in strong wave action and could not be immediately reset until the weather improved. The right bank offshore + left bank passage for the period 9-10 August was expanded by the proportion of the total passage comprised by the right bank nearshore passage from 4-8 August.

## *Species Apportionment*

### Equipment and Procedures

*Set Gillnet Program.* Set-gillnets were fished along the right bank to estimate species composition in the right bank nearshore zone. Gillnets were drifted close enough to the left bank that set gillnets were not necessary there. Set gillnets were 45.7 m (150 ft) long and of four mesh sizes (stretch measure): 7.0 cm (2.75 in), 10.2 cm (4.0 in), 14.0 cm (5.5 in), and 16.5 cm (6.5 in). Set gillnets were secured on the offshore ends to permanent sandbag anchors approximately 45 m offshore and 20 m and 50 m downstream from the right bank nearshore transducer. Gillnets were anchored on the nearshore end by rope leads attached to shoreline trees. Nets were paired so that the 7.0 cm and 14.0 cm nets were always fished together, and the same with the 10.2 cm and 16.5 cm mesh gillnets. The order that mesh pairs were fished in was alternated each tide. The larger mesh gillnet of a pair was always fished at the downstream station. Fishing time was targeted at approximately 20 minutes. Times of net start-out, full-out, start-in and full-in were recorded to the nearest minute for effort calculation. Date, tide, station, set number, species, length and sex of fish caught were recorded on data forms and later entered into an RBASE 2.0 database. Length for salmon species was recorded as mid-eye to fork-of-tail, non-salmon species as snout to tail. Chinook salmon less than 640 mm in length were classified as 'small chinook', those 640 mm or greater in length were classified as 'large chinook'.

*Drift Gillnet Program.* The methods and location used in the 1994 Bethel test fishery are outlined by Molyneaux (1993). To apportion sonar passage estimates to species, nets of 7.0 cm (2.75 in), 10.2 cm (4.0 in), and 16.5 cm (6.5 in) stretched mesh were added to the 20.3 cm (8.0 in) and 13.6 cm (5.4 in) gillnets historically used in the Bethel test fishery. Gillnets were drifted at one of three stations corresponding approximately to: 1) left bank , 2) mid-channel, and 3) right bank. Nets were fished on each tide according to a rotating schedule of three unique permutations of nets to be fished among the three stations (Table 2). Fishing periods began approximately one hour after high tide and continued until all scheduled drifts had been completed. By 10 July daily chinook salmon CPUE in the Bethel test fishery had declined to less than 1% of the total. Use of 20.3-cm mesh gillnets was discontinued at this time and the fishing schedule modified so that the 13.6-cm mesh gillnet was fished once at each station, on every tide (Table 3). Times of net start-out, full-out, start-in and full-in were recorded to the nearest minute for effort calculation. Date, tide, station, drift number, species, length and sex of fish caught were recorded as detailed in set gillnet procedures. Fish caught in set and drift gillnets were sold to a local processor or donated to organizations and individuals.

A 13.7 cm mesh gillnet 8.5 m deep (twice the normal depth) was experimentally drifted from 29 June to 8 July in response to what appeared to be bottom-oriented fish detected by sonar in strata two and three that were too deep to be caught in standard-depth drifted gillnets. This deep net was included in the regular drift gillnet suite after 8 July. On 12 July, a deep 10.2 cm mesh net was also included in the suite of nets drifted at station two. These deep nets were fished only at station 2 (the deepest station) to avoid snags at shallower stations.

## Analytical Methods

*Estimates of Species Proportions*. The procedures used for estimating species proportions were adapted from those of Fleischman et al. (1992) for the lower Yukon River. Daily total fish passage estimates reported by strata were apportioned to species by test fishery data corresponding to stations fished in the test fishery. Estimated fish passage in stratum one (0-40 m) was apportioned by set gillnets (station four). Stratum two (40-190 m) estimated passage was apportioned by test fishery station three. Stratum three (190-260 m) estimated passage was apportioned by test fishery station two. Stratum four (260-350 m) estimated passage was apportioned by test fishery station one. After 29 June, only deep nets were used to apportion chum salmon at station two. Station two and three catches were pooled after this date and used to apportion sonar passage from strata two and three. To maximize sample sizes, test fishery data were pooled into three-day 'report periods.' Report periods were extended when necessary to ensure a total sample size of at least 20 fish.

Species proportions were derived from relative test fishing CPUE, after first adjusting for gillnet mesh selectivity. A SAS program (BTF94.SAS - Appendix A) was used to estimate species proportions and daily fish passage by species. In the program, fishing time $t$ (minutes) for drift $j$ with mesh size $m$ during test-fishing period $f$ at station $s$ in report period $r$ was calculated as

$$t_{rsfmj} = SI - FO + \frac{FO-SO}{2} + \frac{FI-SI}{2}. \tag{4}$$

where $SO$ = net start out, $FO$ = net full out, $SI$ = net start in, and $FI$ = net full in.

To estimate the proportion of species $i$, catch $c$ of species $i$ and length class $l$ during drift $j$ of mesh $m$ during test fishing period $f$ at station $s$ in report period $r$ was first adjusted for net selectivity $S$ of species $i$ and length class $l$ in mesh $m$. Adjusted catch $a$ was calculated as

$$a_{ilrsfmj} = \frac{c_{ilrsfmj}}{S_{ilm}} . \tag{5}$$

If $S_{ilm}$ was undefined because the fish length was outside the range of lengths for which selectivity estimates were available, adjusted catch was set to zero. Length intervals of 40 mm were used for all species other than chinook salmon, for which 100 mm intervals were used. Net selectivity functions for chinook, chum, coho, sockeye, and pink salmon *O. gorbuscha*, as well as whitefish were generated from 6,182 fish captured in the Bethel test fishery in 1991 and 1992 (Figures 3-4). Two or more mesh sizes were used to estimate the abundance of each species (Table 4). For pink salmon, sheefish, and other species lacking selectivity estimates altogether, the mean selectivity for all species ( 0.7) was used for fish regardless of length.

Total effort ($e$) in fathom hours, of drift $j$ with mesh size $m$ during test-fishing period $f$ at station $s$ in report period $r$ was estimated as

$$e_{rsfmj} = \frac{NL \cdot t_{rsfmj}}{60} \tag{6}$$

where $NL$ = net length in fathoms.

CPUE across all drifts $j$ with all mesh sizes $m$, for length class $l$ of species $i$ during test-fishing period $f$ at station $s$ in report period $r$ was calculated as total adjusted catch divided by total effort,

$$CPUE_{ilrsf} = \frac{\sum_m \sum_j a_{ilrsfmj}}{\sum_m \sum_j e_{rsfmj}} . \tag{7}$$

CPUE was then summed across all length categories for each species $i$, and the estimated proportion $p$ of species $i$ during test-fishing period $f$ at station $s$ in report period $r$ was the ratio of CPUE for species $i$ to the total CPUE for all species,

$$\hat{p}_{irsf} = \frac{\sum_l CPUE_{ilrsf}}{\sum_i \sum_l CPUE_{ilrsf}} . \tag{8}$$

For report period $r$ and station $s$, the estimated proportion of species $i$ was estimated as

$$\hat{p}_{irs} = \frac{\sum_f \sum_l CPUE_{ilrsf}}{\sum_f \sum_i \sum_l CPUE_{ilrsf}} \tag{9}$$

which is the equivalent of the mean of all test-fishing period proportions weighted by the total CPUE for all species at each station, in each test-fishing period.

*Fish Passage by Species.* The passage of species $i$ in stratum $s$ for report period $r$ was estimated as

$$\hat{Y}_{irs} = \sum_{d} \hat{y}_{ds} \cdot \hat{p}_{irs} \; . \tag{10}$$

where the summation is over all days in the report period.

Finally, passage estimates were summed over all report periods and strata to obtain a seasonal estimate for species $i$,

$$\hat{Y}_{i} = \sum_{r} \sum_{s} \hat{Y}_{irs} \quad . \tag{11}$$

*Missing Data.* Because species proportions were estimated from pooled three-day periods, the occasional missed drift/set had little effect on estimates of proportions. In the event that a substantial period of time was missed in the test fish program, report periods would have been lengthened to include a minimum sample size of 20 fish.

## RESULTS

### *Hydroacoustic Sampling*

#### Estimates of Daily Total Fish Passage

Total estimated passage for all species combined in the 1994 season was 1,961,356 fish (Tables 5 and 6). Estimated total passage in the four strata of the river cross-section was: 140,265 in the right bank nearshore stratum (7.2%), 1,009,035 in the right bank offshore stratum (51.4%), 453,380 in the unensonified zone (23.1%), and 358,676 (18.3%) in the left bank stratum. The date of 50% passage for all fish species was reached on 4 July. Peak daily passage (81,425) was also on 4 July.

Hydroacoustic sampling on each bank began 5 June and continued through 15 August. On 15 June, an aiming error was discovered on the right bank offshore transducer. The tripod had apparently twisted during deployment so that the transducer was aimed considerably farther upstream than was intended. After the tripod was redeployed and correctly aimed, it became obvious that fish passing on the right bank were considerably more bottom oriented than had been observed in the past. This led to the decision to relocate the offshore transducer to a point approximately 40 m from shore where the shallow slope of the right bank began (Figure 2). This facilitated ensonification of the river bottom throughout the right bank's sampling range.

Transects

A total of 2,174 fish were detected by down-looking sonar transects in 1994. Transect data (unadjusted for probability of detection with depth) indicated that fish in the river's cross-section were primarily oriented to the bottom, and travelled most heavily on the right bank (Figure 5).

In the original project design, estimated passage in the unensonified zone based on fish detected by down-looking sonar was 'calibrated' to side-looking passage estimates. This was done by comparing proportions of fish detected by side-looking gear in the last approximately 25% of each bank's sampling range with proportions of down-looking fish in the same areas. After 9 June, concerns that the calibration technique was artificially inflating unensonified zone passage estimates prompted a thorough review of the procedure. Mathematical derivation indicated that the calibration technique was inappropriate and actually increased the variability of unensonified zone estimates. Consequently, on 6 July the use of the calibration technique was discontinued. At the same time, the range distribution of fish detected in down-looking transects adjusted for probability of detection with depth also showed visibly higher relative passage in the zones within 50 m of each bank than observed with side-looking sonar (Figure 6). Therefore, we used transect data only from 50-300 m to expand fish in the unensonified zone. We also limited the expansion factor C (equation 3) of detected fish to a value corresponding to fish detected at 1.5 m (5) ft. This avoided the over-expansion of fish detected at very shallow depths. Unensonified zone estimates were recalculated from the beginning of the season using this modified approach.

Duplicate transects were performed where depth was measured at known distances from shore to estimate the bottom slope angle of the right bank nearshore. Assuming the sonar beam would extend to a point 20 m beyond the inflection of the right bank's complex slope, the two transects yielded bottom slope angles of 6.8° and 7.6° (Figure 7).

*Species Apportionment*

Total passage estimates included 110,445 chinook, 307,319 sockeye, 779,037 chum, 405,903 coho, and 40,022 pink salmon (Table 6). Chinook salmon passage is divided into small chinook (< 640 mm; 44,369 fish) and large chinook (≥ 640 mm; 66,076 fish). Total passage estimates of non-salmon species included 124,097 whitefish (broad and humpback), 184,066 least cisco, and 10,467 fish of other species (e.g. northern pike *Esox lucius*, burbot *Lota lota*, dolly varden *Salvelinus malma*, sheefish *Stenodus leucichthys*) .

Deep gillnets (8.5 m, 28.0 ft), twice the standard depth (4.3 m, 14.0 ft), drifted experimentally during the period 29 June-8 July caught chum salmon 6.4 times more frequently in the lower half (122 fish) than in the upper half (19 fish). Based on this information, deep gillnets of mesh sizes 10.2 cm and 13.7 cm were added to the suite of nets used for estimating species proportions. For all drifts with deep nets, 201 chum salmon were caught in the lower half of the net compared to 42 caught in the upper half. Chinook, sockeye and coho salmon also showed higher catch rates in the lower half of deep nets.

The daily pattern of salmon species passage approximately matched the pattern of daily CPUE for each species from the Bethel test fishery, with the exception of coho salmon (Figures 8-11). Cumulative percent passage of all salmon species from sonar estimates and test fishery CPUE tracked reasonably closely together (Figures 12-15). In contrast to Figures 8-11, coho salmon actually showed the best correlation ($R^2 = 0.68$) between test fishery CPUE and sonar passage (Figures 16-19). Variability of sonar passage was not adequately explained by the variation in test fishery CPUE in other species ($R^2 < 0.50$).

Plots that compared total sonar passage of all species by stratum with test fish CPUE for all species for the corresponding station were used inseason to corroborate sonar fish detection in each stratum. Test fish CPUE and total sonar passage trended closely for the left bank (Figure 20). Similarly, pooled sonar passage in strata two and three closely followed test fish CPUE pooled across stations two and three (Figure 21). Set gillnet CPUE did not appear to follow sonar passage in the right bank nearshore stratum (one) as closely as the above two comparisons (Figure 22). Small proportions of daily sonar passage variability was explained by variation in test fish CPUE in analyses by stratum (Figures 23-25). The correlation of set gillnet CPUE and stratum one passage was particularly poor ($R^2 = 0.05$).

A total of 1,056 fish were caught in set gillnets deployed in the 0-40 m zone of the right bank. Managed species (chinook, sockeye, chum, coho salmon) made up 35.1% of all fish captured in set gillnets. Least cisco comprised 41.5% of the catch. After 15 July, coho salmon were the only managed salmon species present in appreciable numbers (13.7 %). Least cisco made up 60.0% of the set gillnet catch after 15 July.

## DISCUSSION

### *Hydroacoustic Sampling*

The total fish passage estimate of 1,961,356 in 1994 represents a 30% increase over total estimated passage in 1993. Approximately 80% of this increase is accounted for by the increase in chum salmon abundance from 422,862 in 1993 to 779,037 in 1994. Right bank total passage estimate was 3.2 times that of left bank. This is markedly different from 1993, when right and left bank passage were nearly equal. The left bank pattern of passage with range for 1994 is also very different than that found in 1993 (Figure 26). While a full explanation of why the passage at range patterns on the left bank in these two years are nearly mirror images of each other is not apparent, the high mean passage in the first 20 m seen in 1993 may be explained by the relatively low threshold (-52.4 dBv as opposed to -40 dBv in 1994). Thus, very small fish in the first 20 m of the left bank in 1993 may have inflated passage estimates in this zone in 1993.

A transducer with a larger beam angle would help to more completely sample the cross-section of the right bank nearshore stratum, thus increasing accuracy of total fish passage estimates from this stratum. A beam angle should be selected sufficiently smaller than 6.8° so that surface reverberation noise will not be a problem. A transducer with a beam angle of approximately 6° would be optimum, provided the bottom profile does not change.

The distribution of fish detected with down-looking sonar indicates that the majority of fish passing the sonar site in 1994 were bottom oriented, and utilized the right bank more than the left. This agrees with the range distribution indicated by side-looking sonar (Figure 6). Fish distribution from down-looking sonar suggests that fish in 1994 were more bottom-oriented than in 1993 (Figures 5, 27).

*Species Apportionment*

All managed salmon species passage estimates increased in 1994 over estimates from 1993. Most notably, chum salmon abundance at the sonar site in 1994 was nearly double the 422,862 estimated in 1993. Chinook, sockeye, and coho salmon passage estimates by 19%, 9%, and 28%, respectively. In 1994, broad and humpback whitefish were lumped together as 'whitefish' in passage estimates. The only species of cisco observed in the Bethel test fishery was the least cisco. Non-salmon species passing in 1994 were predominantly least cisco (58%), followed by whitefish species (39%).

The poor fit of test fish CPUE to sonar passage, both for individual species (Figures 16-19) and for all species by stratum (Figures 23-25) shows that the timing and magnitude of these two variables do not vary closely when constrained to 24-h periods of time. Correlations of sonar passage vs. CPUE for each tide should have better results, since test fish results vary more by tide than on a daily basis. The bar-line graphs of sonar passage and test fish daily CPUE (Figures 8-11, 20-22) demonstrate that a reasonably close relationship between the two does exist. The particularly poor correlation of right bank nearshore CPUE and passage for all species (Figure 25) may indicate less complete detection of fish by sonar in this stratum than in other strata. This may be explained by fish being missed above the 4° beam used on the right bank nearshore. Ciscos tended to be caught in the inshore end of the set gillnets. The corresponding inshore portion of the sonar beam was still quite small, and fish could easily be missed. It is also possible that some ciscos and whitefish were not detected because of the -40 dBv threshold in place. At the sonar beam's half power point, the smallest fish detectable was -34 dBv. It is possible that smaller ciscos susceptible to set gillnets of 7.0 and 10.2 cm may have target strengths smaller than -34 dBv. However, passage in this stratum is relatively low (approximately 6.5% of total river in 1994), thus the effect of errors in the right bank nearshore stratum was relatively small on total river estimates.

The greater chum salmon catch in the lower half of deep nets is matched by the qualitative observations of bottom-oriented fish with both side-looking and down-looking sonar. Any significant raising of side-looking sonar beams from the bottom caused a noticeable drop in the number of fish detected. Sample sizes of sockeye and chinook salmon caught in deep nets were too small (6 and 29, respectively) to be conclusive as to which panel these species are caught in most. Coho salmon were caught 34% more in the lower panel than in the upper panel. The higher catch of coho salmon in the lower panels than the upper is surprising, since test fish crews occasionally reported that shallow nets (i.e. standard 4.3 m depth) were considerably more efficient at catching coho salmon than were deep nets of the same mesh size. Other work has shown that coho salmon may be more susceptible to capture by shallow nets, but differences were not statistically significant (Jeff Bromaghin, Alaska Department of Fish and Game, Personal Communication).

The 1,056 fish caught in the right bank set gillnets was more than double the 1993 catch of 515 fish. We feel this is due to a more effective system of fishing set gillnets on the right bank nearshore, specifically the use of permanent offshore anchors. In 1993, the offshore ends of set gillnets were anchored by Danforth or Navy anchors, which were often insufficient to hold nets perpendicular to the current. Thus, nets often did not fish effectively in 1993 because the offshore end swung considerably downstream in the current.

## RECOMMENDATIONS

1. A suite of deep gillnets (8.5 m deep) of mesh sizes 20.3 cm (8.0 in), 16.5 cm (6.5 in), 13.7 cm (5.4 in) and 10.2 cm (4.0 in) should be drifted at station 2 in 1994 to more accurately estimate species proportions.

2. A transducer with a wider beam angle (6°) should be considered for sampling the right bank nearshore to more completely sample fish passage in this stratum.

3. A procedure should be established to determine defensible side-aspect target strength thresholds for future hydroacoustic sampling on the Kuskokwim River.

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Table 1. Sonar system parameters used after 18 June, 1994.

| Right Bank Nearshore | Right Bank Offshore | Left Bank |
|---|---|---|
| • Range 50 meters | • Range 140 meters | • Range 90 meters |
| • Ping rate 4.0 $sec^{-1}$ | • Ping rate 4.0 $sec^{-1}$ | • Ping rate 4.0 $sec^{-1}$ |
| • Chart recorder thrshld 1.16 V | • Chart recorder thrshld 0.46 V | • Chart recorder thrshld 0.67 V |
| • Recvr gain 0 db | • Rcvr gain -12 db | • Rcvr gain -6 db |
| • Trnsmit pwr -13 db | • Trnsmit pwr -10 db | • Trnsmit pwr -13 db |
| • target strength thrshld -40 dBv | • target strength thrshld -40 dBv | • target strength thrshld -40 dBv |
| • Pulse width .4 | • Pulse width .4 | • Pulse width .4 |
| •Blank at range enabled | •Blank at range enabled | •Blank at range enabled |

Table 2. Drift schedule used to determine sequence (in parentheses) of stations and mesh sizes (in) fished during each tidal drift series during the period 1 June-10 July, 1994.

| Schedule Number | Station Number | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | 8.0 (1) | | 8.0 (2) |
| | | 5.4 (3) | 5.4 (4) |
| | 6.5 (5) | 6.5 (6) | |
| | 4.0 (8) | | 4.0 (7) |
| 2 | 8.0 (1) | 8.0 (2) | |
| | 5.4 (4) | | 5.4 (3) |
| | | 6.5 (5) | 6.5 (6) |
| | 4.0 (7) | 4.0 (8) | |
| 3 | | 8.0 (1) | 8.0 (2) |
| | 5.4 (3) | 5.4 (4) | |
| | 6.5 (6) | | 6.5 (5) |
| | | 4.0 (7) | 4.0 (8) |

Table 3. Drift schedule used to determine sequence (in parentheses) of stations and mesh sizes (in) fished during each tidal drift series from 11 July-31 August, 1994.

| Schedule Number | Station Number | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | 5.4 (3) | 5.4 (1) | 5.4 (2) |
| | | 6.5 (4) | 6.5 (5) |
| | 4.0 (6) | 4.0 (7) | |
| | 2.7(9) | | 2.7(8) |
| 2 | 5.4 (2) | 5.4 (3) | 5.4 (1) |
| | 6.5 (5) | | 6.5 (4) |
| | | 4.0 (6) | 4.0 (7) |
| | 2.7(8) | 2.7(9) | |
| 3 | 5.4 (1) | 5.4 (2) | 5.4 (3) |
| | 6.5 (4) | 6.5 (5) | |
| | 4.0 (7) | 4.0 (6) | |
| | | 2.7(8) | 2.7(9) |

Table 4. Mesh sizes used to determine relative abundance of fish species present in the Kuskokwim River, 1994.

| Species | Gillnet Mesh Size (in) | | | | |
|---|---|---|---|---|---|
| | 2.75 | 4.0 | 5.4 | 6.5 | 8.0 |
| Large Chinook | | | X | X | X |
| Small Chinook | | X | X | X | X |
| Sockeye | | X | X | X | X |
| Chum | | X | X | X | X |
| Pink | | X | X | | |
| Coho | | X | X | X | |
| Whitefish | X | X | X | | |
| Cisco | X | X | | | |
| Other | | X | X | X | |

Table 5. Daily estimated fish passage by species in the Kuskokwim River at Bethel, 1994.

| Date | Large Chinook | Small Chinook | Sockeye | Chum | Coho | Pink | Whitefish | Cisco | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 01-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 03-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 04-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 05-Jun | 1876 | 3340 | 0 | 1308 | 0 | 0 | 66 | 0 | 377 | 6967 |
| 06-Jun | 1727 | 2874 | 0 | 1162 | 0 | 0 | 57 | 0 | 385 | 6205 |
| 07-Jun | 1378 | 2338 | 0 | 936 | 0 | 0 | 46 | 0 | 299 | 4997 |
| 08-Jun | 2443 | 2067 | 0 | 2347 | 0 | 0 | 544 | 0 | 0 | 7401 |
| 09-Jun | 2104 | 1894 | 0 | 2129 | 0 | 0 | 630 | 0 | 0 | 6757 |
| 10-Jun | 2274 | 1987 | 0 | 2244 | 0 | 0 | 595 | 0 | 0 | 7100 |
| 11-Jun | 1142 | 2051 | 17 | 2368 | 0 | 0 | 356 | 0 | 494 | 6428 |
| 12-Jun | 1385 | 2467 | 21 | 2835 | 0 | 0 | 447 | 0 | 595 | 7750 |
| 13-Jun | 2457 | 4546 | 40 | 5349 | 0 | 0 | 654 | 0 | 1088 | 14134 |
| 14-Jun | 3018 | 1516 | 673 | 8639 | 0 | 0 | 638 | 0 | 271 | 14755 |
| 15-Jun | 2994 | 1490 | 661 | 8625 | 0 | 0 | 529 | 0 | 274 | 14573 |
| 16-Jun | 3357 | 1708 | 758 | 9518 | 0 | 0 | 873 | 0 | 294 | 16508 |
| 17-Jun | 1567 | 864 | 1297 | 10063 | 0 | 0 | 309 | 108 | 42 | 14250 |
| 18-Jun | 1402 | 695 | 1105 | 8516 | 0 | 0 | 312 | 112 | 40 | 12182 |
| 19-Jun | 1509 | 972 | 1380 | 10798 | 0 | 0 | 236 | 69 | 39 | 15003 |
| 20-Jun | 1969 | 800 | 3127 | 14513 | 0 | 0 | 37 | 0 | 10 | 20456 |
| 21-Jun | 1291 | 518 | 2319 | 10473 | 0 | 0 | 42 | 0 | 19 | 14662 |
| 22-Jun | 977 | 428 | 2044 | 8108 | 0 | 0 | 88 | 0 | 17 | 11662 |
| 23-Jun | 2080 | 298 | 10509 | 14913 | 0 | 0 | 0 | 0 | 228 | 28028 |
| 24-Jun | 1643 | 245 | 8971 | 12785 | 0 | 0 | 0 | 0 | 221 | 23865 |
| 25-Jun | 3616 | 520 | 18449 | 24831 | 0 | 0 | 0 | 0 | 450 | 47866 |
| 26-Jun | 4270 | 2355 | 22189 | 12742 | 0 | 0 | 1340 | 0 | 0 | 42896 |
| 27-Jun | 2372 | 1305 | 12803 | 7328 | 0 | 0 | 715 | 0 | 0 | 24523 |
| 28-Jun | 2262 | 1150 | 12112 | 6874 | 0 | 0 | 750 | 0 | 0 | 23148 |
| 29-Jun | 1656 | 617 | 8984 | 11898 | 0 | 0 | 2008 | 110 | 211 | 25484 |
| 30-Jun | 1713 | 659 | 9093 | 12010 | 0 | 0 | 2020 | 126 | 236 | 25857 |
| 01-Jul | 2290 | 826 | 12622 | 16755 | 0 | 0 | 2814 | 137 | 273 | 35717 |
| 02-Jul | 845 | 738 | 32130 | 34506 | 42 | 0 | 4831 | 238 | 193 | 73523 |
| 03-Jul | 819 | 716 | 31173 | 33404 | 41 | 0 | 4850 | 249 | 187 | 71439 |
| 04-Jul | 926 | 809 | 35347 | 37827 | 46 | 0 | 5928 | 331 | 211 | 81425 |
| 05-Jul | 508 | 249 | 13831 | 43627 | 0 | 0 | 2764 | 474 | 288 | 61741 |
| 06-Jul | 573 | 273 | 15299 | 48374 | 0 | 0 | 3059 | 520 | 328 | 68426 |
| 07-Jul | 431 | 184 | 10666 | 34294 | 0 | 0 | 2067 | 300 | 239 | 48181 |
| 08-Jul | 488 | 0 | 4448 | 40337 | 677 | 27 | 964 | 442 | 32 | 47415 |
| 09-Jul | 502 | 0 | 4912 | 45957 | 729 | 32 | 1018 | 408 | 33 | 53591 |
| 10-Jul | 392 | 0 | 3484 | 31224 | 534 | 20 | 772 | 368 | 25 | 36819 |
| 11-Jul | 522 | 0 | 4852 | 19947 | 2109 | 187 | 6391 | 2399 | 336 | 36743 |
| 12-Jul | 432 | 0 | 3939 | 15845 | 1717 | 159 | 4769 | 1750 | 263 | 28874 |
| 13-Jul | 328 | 0 | 3085 | 12808 | 1335 | 117 | 4207 | 1583 | 218 | 23681 |
| 14-Jul | 183 | 0 | 1382 | 13736 | 1525 | 230 | 7851 | 5381 | 0 | 30288 |
| 15-Jul | 177 | 0 | 1032 | 10278 | 1303 | 222 | 5971 | 3925 | 0 | 22908 |
| 16-Jul | 158 | 0 | 1418 | 13655 | 1729 | 213 | 7900 | 5680 | 0 | 30753 |
| 17-Jul | 60 | 81 | 3319 | 14726 | 1743 | 939 | 9599 | 7046 | 589 | 38102 |
| 18-Jul | 57 | 77 | 3172 | 13895 | 1485 | 782 | 8804 | 5520 | 534 | 34326 |
| 19-Jul | 77 | 103 | 2504 | 11857 | 1279 | 713 | 7648 | 4116 | 403 | 28700 |
| 20-Jul | 0 | 0 | 196 | 4668 | 425 | 2379 | 2204 | 10301 | 0 | 20173 |
| 21-Jul | 0 | 0 | 130 | 3561 | 334 | 1896 | 1874 | 9658 | 0 | 17453 |
| 22-Jul | 0 | 0 | 164 | 4528 | 377 | 2409 | 2302 | 12112 | 0 | 21892 |
| 23-Jul | 413 | 0 | 367 | 6999 | 1081 | 6419 | 963 | 4417 | 177 | 20836 |
| 24-Jul | 753 | 0 | 668 | 11921 | 1621 | 11197 | 1591 | 6290 | 283 | 34324 |
| 25-Jul | 659 | 0 | 585 | 10433 | 1358 | 9778 | 1370 | 5297 | 240 | 29720 |
| 26-Jul | 0 | 0 | 0 | 4610 | 1690 | 10410 | 761 | 2443 | 7 | 19921 |
| 27-Jul | 0 | 0 | 0 | 4020 | 1510 | 8975 | 694 | 2557 | 9 | 17765 |
| 28-Jul | 0 | 0 | 0 | 4603 | 1718 | 10313 | 786 | 2799 | 9 | 20228 |
| 29-Jul | 0 | 0 | 0 | 1649 | 975 | 13339 | 720 | 5612 | 0 | 22295 |
| 30-Jul | 0 | 0 | 0 | 1731 | 1085 | 14050 | 883 | 6682 | 0 | 24431 |
| 31-Jul | 0 | 0 | 0 | 1498 | 1008 | 12193 | 913 | 6709 | 0 | 22321 |
| 01-Aug | 0 | 149 | 0 | 2382 | 1709 | 13358 | 624 | 5113 | 0 | 23335 |
| 02-Aug | 0 | 214 | 0 | 3292 | 2268 | 17203 | 599 | 6174 | 0 | 29750 |
| 03-Aug | 0 | 246 | 0 | 3785 | 2547 | 19568 | 611 | 6643 | 0 | 33400 |
| 04-Aug | 0 | 0 | 0 | 767 | 713 | 7129 | 371 | 11257 | 0 | 20237 |
| 05-Aug | 0 | 0 | 0 | 577 | 543 | 5524 | 298 | 9198 | 0 | 16140 |
| 06-Aug | 0 | 0 | 0 | 715 | 656 | 6743 | 355 | 10799 | 0 | 19268 |
| 07-Aug | 0 | 0 | 0 | 234 | 485 | 15658 | 49 | 2551 | 0 | 18977 |
| 08-Aug | 0 | 0 | 0 | 394 | 811 | 25979 | 82 | 4256 | 0 | 31522 |
| 09-Aug | 0 | 0 | 0 | 303 | 593 | 19944 | 58 | 3088 | 0 | 23986 |
| 10-Aug | 0 | 0 | 17 | 0 | 103 | 27444 | 176 | 2843 | 0 | 30583 |
| 11-Aug | 0 | 0 | 16 | 0 | 55 | 40308 | 163 | 1178 | 0 | 41720 |
| 12-Aug | 0 | 0 | 10 | 0 | 37 | 26909 | 99 | 857 | 0 | 27912 |
| 13-Aug | 0 | 0 | 0 | 0 | 8 | 17867 | 15 | 1105 | 0 | 18995 |
| 14-Aug | 0 | 0 | 0 | 0 | 9 | 31550 | 17 | 1383 | 0 | 32959 |
| 15-Aug | 0 | 0 | 0 | 0 | 11 | 23718 | 21 | 1355 | 0 | 25105 |

Table 6. Cumulative estimated fish passage by species in the Kuskokwim River at Bethel, 1994.

| Date | Large Chinook | Small Chinook | Sockeye | Chum | Coho | Pink | Whitefish | Cisco | Other | Total | Cumulativ Date |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 01-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 01-Jun |
| 02-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 02-Jun |
| 03-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30-Dec |
| 04-Jun | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30-Dec |
| 05-Jun | 1876 | 3340 | 0 | 1308 | 0 | 0 | 66 | 0 | 377 | 6967 | 30-Dec |
| 06-Jun | 3603 | 6214 | 0 | 2469 | 0 | 0 | 123 | 0 | 762 | 13171 | 30-Dec |
| 07-Jun | 4981 | 8552 | 0 | 3406 | 0 | 0 | 169 | 0 | 1060 | 18168 | 11-Jan |
| 08-Jun | 7424 | 10619 | 0 | 5753 | 0 | 0 | 713 | 0 | 1060 | 25569 | 31-Jan |
| 09-Jun | 9528 | 12513 | 0 | 7882 | 0 | 0 | 1343 | 0 | 1060 | 32326 | 25-Nov |
| 10-Jun | 11802 | 14500 | 0 | 10126 | 0 | 0 | 1938 | 0 | 1060 | 39426 | 25-Nov |
| 11-Jun | 12944 | 16551 | 17 | 12494 | 0 | 0 | 2294 | 0 | 1554 | 45854 | 25-Nov |
| 12-Jun | 14330 | 19018 | 38 | 15330 | 0 | 0 | 2741 | 0 | 2150 | 53607 | 25-Nov |
| 13-Jun | 16787 | 23565 | 78 | 20679 | 0 | 0 | 3395 | 0 | 3238 | 67742 | 02-Apr |
| 14-Jun | 19806 | 25081 | 750 | 29318 | 0 | 0 | 4033 | 0 | 3509 | 82497 | 19-Nov |
| 15-Jun | 22799 | 26571 | 1411 | 37943 | 0 | 0 | 4562 | 0 | 3783 | 97069 | 11-Nov |
| 16-Jun | 26157 | 28279 | 2169 | 47461 | 0 | 0 | 5435 | 0 | 4077 | 113578 | 09-Aug |
| 17-Jun | 27723 | 29143 | 3466 | 57524 | 0 | 0 | 5744 | 108 | 4119 | 127827 | 10-May |
| 18-Jun | 29125 | 29837 | 4572 | 66040 | 0 | 0 | 6056 | 220 | 4160 | 140010 | 28-Feb |
| 19-Jun | 30634 | 30809 | 5952 | 76838 | 0 | 0 | 6292 | 289 | 4199 | 155013 | 11-Apr |
| 20-Jun | 32603 | 31609 | 9079 | 91351 | 0 | 0 | 6329 | 289 | 4209 | 175469 | 22-May |
| 21-Jun | 33893 | 32127 | 11398 | 101824 | 0 | 0 | 6371 | 289 | 4228 | 190130 | 30-Jun |
| 22-Jun | 34870 | 32555 | 13442 | 109933 | 0 | 0 | 6458 | 289 | 4245 | 201792 | 10-Jul |
| 23-Jun | 36950 | 32853 | 23951 | 124846 | 0 | 0 | 6458 | 289 | 4474 | 229821 | 29-Jul |
| 24-Jun | 38593 | 33099 | 32922 | 137630 | 0 | 0 | 6458 | 289 | 4695 | 253686 | 15-Aug |
| 25-Jun | 42209 | 33619 | 51371 | 162461 | 0 | 0 | 6458 | 289 | 5145 | 301552 | 31-Mar |
| 26-Jun | 46480 | 35974 | 73560 | 175203 | 0 | 0 | 7798 | 289 | 5145 | 344449 | 07-Nov |
| 27-Jun | 48851 | 37279 | 86362 | 182532 | 0 | 0 | 8513 | 289 | 5145 | 368971 | 31-Jan |
| 28-Jun | 51114 | 38429 | 98475 | 189405 | 0 | 0 | 9263 | 289 | 5145 | 392120 | 31-Jan |
| 29-Jun | 52770 | 39046 | 107458 | 201303 | 0 | 0 | 11272 | 399 | 5356 | 417604 | 31-Jan |
| 30-Jun | 54483 | 39705 | 116551 | 213313 | 0 | 0 | 13292 | 524 | 5592 | 443460 | 31-Jan |
| 01-Jul | 56774 | 40531 | 129174 | 230068 | 0 | 0 | 16106 | 662 | 5865 | 479180 | 30-Aug |
| 02-Jul | 57618 | 41269 | 161303 | 264574 | 42 | 0 | 20937 | 900 | 6057 | 552700 | 23-Apr |
| 03-Jul | 58437 | 41985 | 192476 | 297977 | 83 | 0 | 25786 | 1149 | 6244 | 624137 | 21-Jan |
| 04-Jul | 59363 | 42793 | 227823 | 335804 | 129 | 0 | 31715 | 1480 | 6455 | 705562 | 31-Jul |
| 05-Jul | 59871 | 43042 | 241654 | 379431 | 129 | 0 | 34479 | 1954 | 6743 | 767303 | 03-Feb |
| 06-Jul | 60443 | 43315 | 256953 | 427805 | 129 | 0 | 37538 | 2474 | 7071 | 835728 | 02-Sep |
| 07-Jul | 60874 | 43498 | 267619 | 462100 | 129 | 0 | 39605 | 2774 | 7310 | 883909 | 17-Jun |
| 08-Jul | 61362 | 43498 | 272068 | 502437 | 806 | 27 | 40569 | 3216 | 7342 | 931325 | 11-May |
| 09-Jul | 61864 | 43498 | 276979 | 548394 | 1535 | 58 | 41587 | 3624 | 7374 | 984913 | 05-Jan |
| 10-Jul | 62256 | 43498 | 280464 | 579618 | 2069 | 79 | 42359 | 3992 | 7400 | 1021735 | 06-Feb |
| 11-Jul | 62777 | 43498 | 285315 | 599565 | 4177 | 266 | 48750 | 6391 | 7736 | 1058475 | 09-Mar |
| 12-Jul | 63209 | 43498 | 289255 | 615410 | 5894 | 426 | 53519 | 8141 | 7999 | 1087351 | 04-Apr |
| 13-Jul | 63537 | 43498 | 292339 | 628218 | 7229 | 543 | 57726 | 9724 | 8217 | 1111031 | 06-Mar |
| 14-Jul | 63720 | 43498 | 293722 | 641955 | 8754 | 773 | 65577 | 15105 | 8217 | 1141321 | 24-Nov |
| 15-Jul | 63897 | 43498 | 294754 | 652232 | 10057 | 995 | 71548 | 19030 | 8217 | 1164228 | 30-Jun |
| 16-Jul | 64055 | 43498 | 296171 | 665887 | 11786 | 1209 | 79448 | 24710 | 8217 | 1194981 | 30-Jun |
| 17-Jul | 64116 | 43579 | 299490 | 680613 | 13529 | 2147 | 89047 | 31756 | 8805 | 1233082 | 30-Jun |
| 18-Jul | 64173 | 43656 | 302663 | 694508 | 15014 | 2929 | 97851 | 37275 | 9339 | 1267408 | 30-Jun |
| 19-Jul | 64250 | 43759 | 305167 | 706366 | 16293 | 3643 | 105499 | 41392 | 9742 | 1296111 | 08-Feb |
| 20-Jul | 64250 | 43759 | 305363 | 711034 | 16718 | 6022 | 107703 | 51693 | 9742 | 1316284 | 26-Jul |
| 21-Jul | 64250 | 43759 | 305492 | 714595 | 17052 | 7918 | 109577 | 61351 | 9742 | 1333736 | 02-Sep |
| 22-Jul | 64250 | 43759 | 305656 | 719122 | 17429 | 10327 | 111879 | 73462 | 9742 | 1355626 | 02-Sep |
| 23-Jul | 64664 | 43759 | 306023 | 726121 | 18510 | 16746 | 112842 | 77879 | 9919 | 1376463 | 02-Sep |
| 24-Jul | 65417 | 43759 | 306691 | 738042 | 20131 | 27943 | 114433 | 84169 | 10202 | 1410787 | 02-Sep |
| 25-Jul | 66076 | 43759 | 307276 | 748475 | 21488 | 37721 | 115802 | 89466 | 10442 | 1440505 | 26-Feb |
| 26-Jul | 66076 | 43759 | 307276 | 753085 | 23179 | 48131 | 116564 | 91909 | 10449 | 1460428 | 06-Dec |
| 27-Jul | 66076 | 43759 | 307276 | 757105 | 24688 | 57106 | 117258 | 94466 | 10458 | 1478192 | 02-Aug |
| 28-Jul | 66076 | 43759 | 307276 | 761708 | 26407 | 67420 | 118043 | 97265 | 10467 | 1498421 | 09-Aug |
| 29-Jul | 66076 | 43759 | 307276 | 763357 | 27381 | 80759 | 118764 | 102877 | 10467 | 1520716 | 18-Aug |
| 30-Jul | 66076 | 43759 | 307276 | 765088 | 28466 | 94808 | 119646 | 109559 | 10467 | 1545145 | 27-Aug |
| 31-Jul | 66076 | 43759 | 307276 | 766587 | 29475 | 107002 | 120559 | 116269 | 10467 | 1567470 | 27-Aug |
| 01-Aug | 66076 | 43908 | 307276 | 768969 | 31184 | 120359 | 121183 | 121382 | 10467 | 1590804 | 27-Aug |
| 02-Aug | 66076 | 44122 | 307276 | 772261 | 33452 | 137563 | 121782 | 127556 | 10467 | 1620555 | 27-Aug |
| 03-Aug | 66076 | 44369 | 307276 | 776046 | 36000 | 157131 | 122393 | 134199 | 10467 | 1653957 | 27-Aug |
| 04-Aug | 66076 | 44369 | 307276 | 776813 | 36713 | 164260 | 122764 | 145455 | 10467 | 1674193 | 27-Aug |
| 05-Aug | 66076 | 44369 | 307276 | 777390 | 37256 | 169783 | 123061 | 154653 | 10467 | 1690331 | 27-Aug |
| 06-Aug | 66076 | 44369 | 307276 | 778105 | 37912 | 176526 | 123416 | 165452 | 10467 | 1709599 | 27-Aug |
| 07-Aug | 66076 | 44369 | 307276 | 778340 | 38397 | 192184 | 123465 | 168002 | 10467 | 1728576 | 27-Aug |
| 08-Aug | 66076 | 44369 | 307276 | 778734 | 39208 | 218163 | 123547 | 172258 | 10467 | 1760098 | 27-Aug |
| 09-Aug | 66076 | 44369 | 307276 | 779037 | 39800 | 238107 | 123605 | 175346 | 10467 | 1784083 | 27-Aug |
| 10-Aug | 66076 | 44369 | 307293 | 779037 | 39904 | 265551 | 123781 | 178189 | 10467 | 1814667 | 27-Aug |
| 11-Aug | 66076 | 44369 | 307310 | 779037 | 39958 | 305859 | 123944 | 179367 | 10467 | 1856387 | 27-Aug |
| 12-Aug | 66076 | 44369 | 307319 | 779037 | 39995 | 332768 | 124044 | 180224 | 10467 | 1884299 | 27-Aug |
| 13-Aug | 66076 | 44369 | 307319 | 779037 | 40003 | 350635 | 124059 | 181329 | 10467 | 1903294 | 27-Aug |
| 14-Aug | 66076 | 44369 | 307319 | 779037 | 40012 | 382185 | 124076 | 182711 | 10467 | 1936252 | 27-Aug |
| 15-Aug | 66076 | 44369 | 307319 | 779037 | 40022 | 405903 | 124097 | 184066 | 10467 | 1961356 | 10467 |

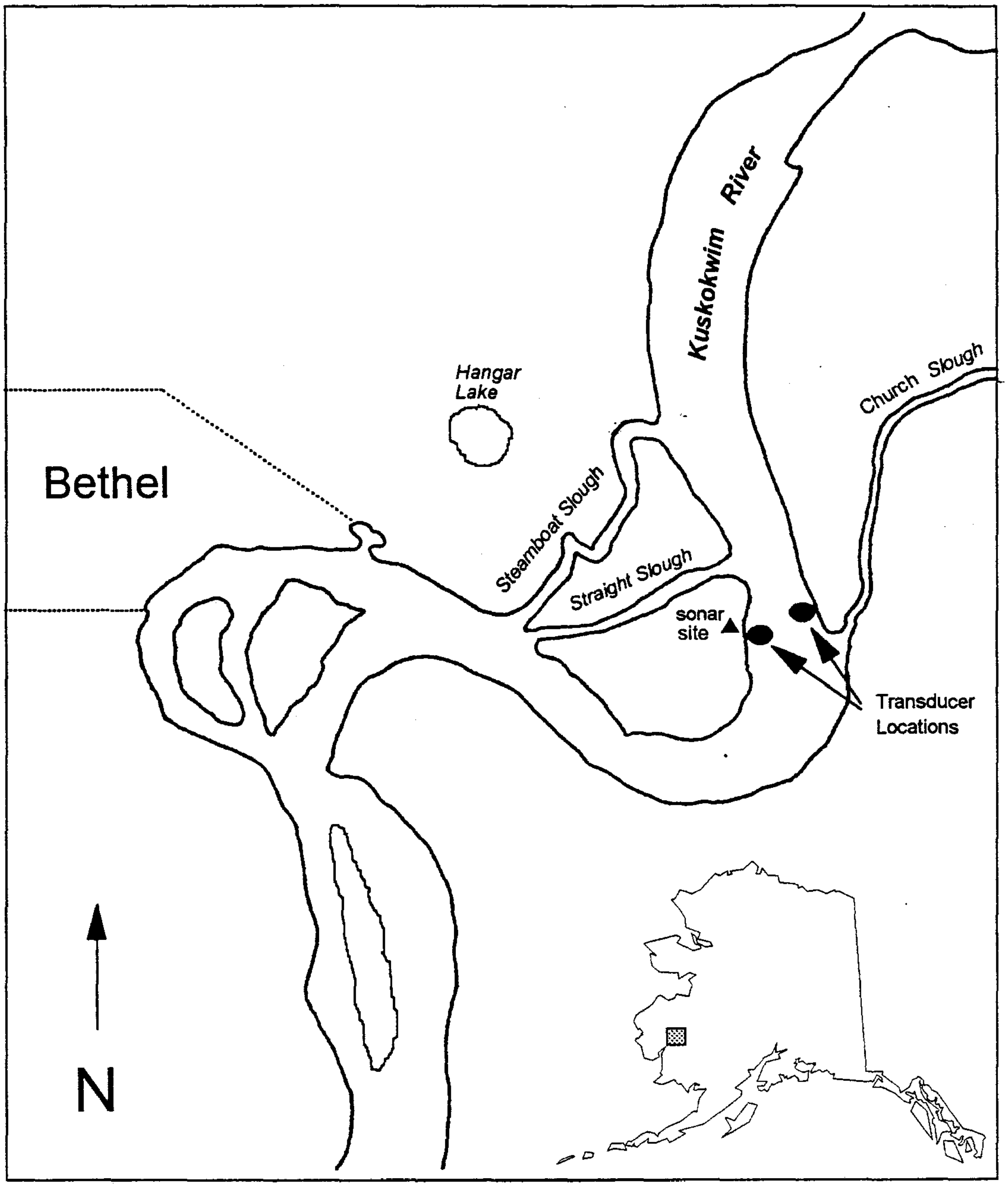


Figure 1. Map of the Kuskokwim River showing location of the 1994 sonar site.

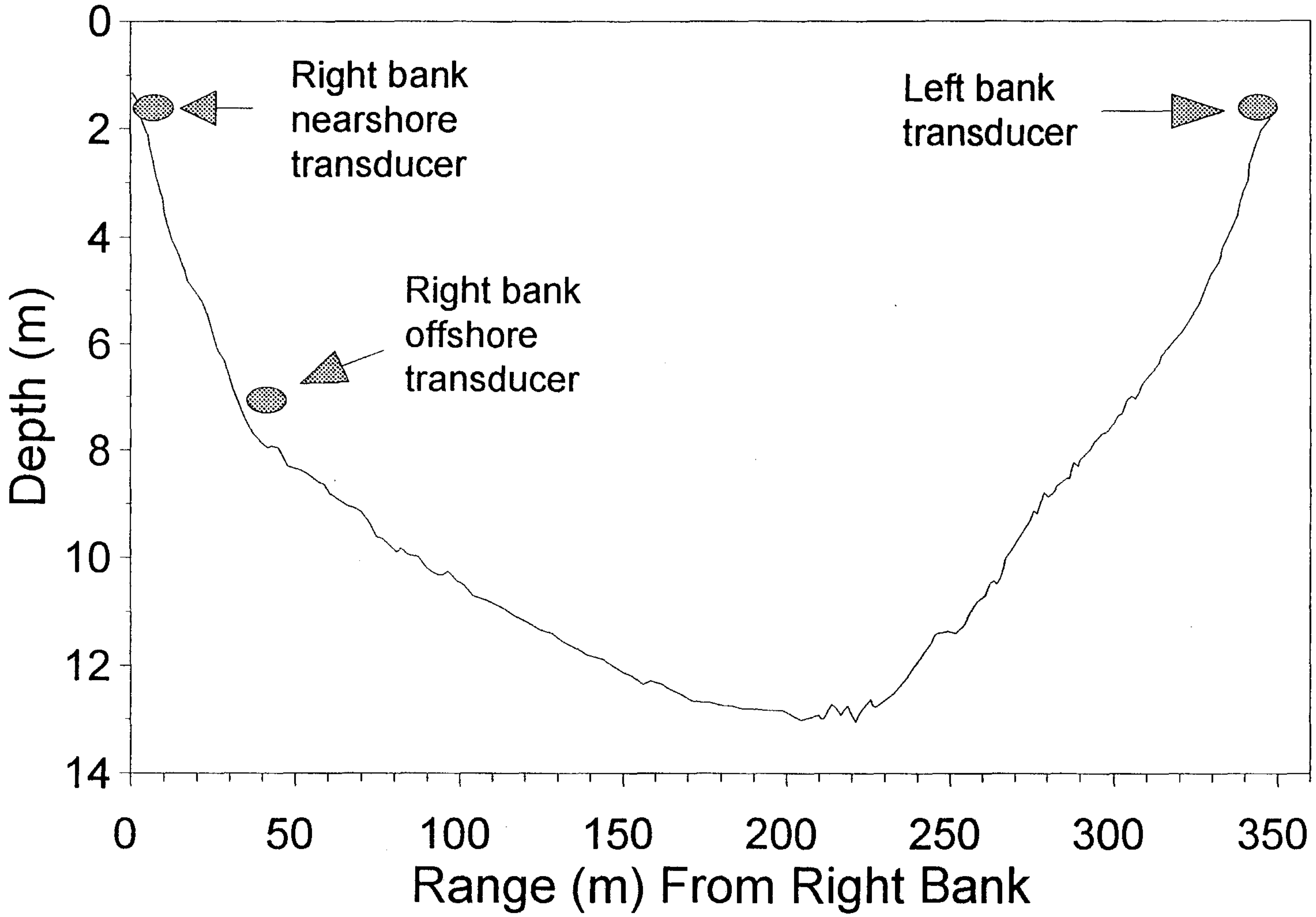


Figure 2. Bottom profile at the Kuskokwim River sonar site from six digitized transects on 18 June, 1994. Locations of transducers are shown.

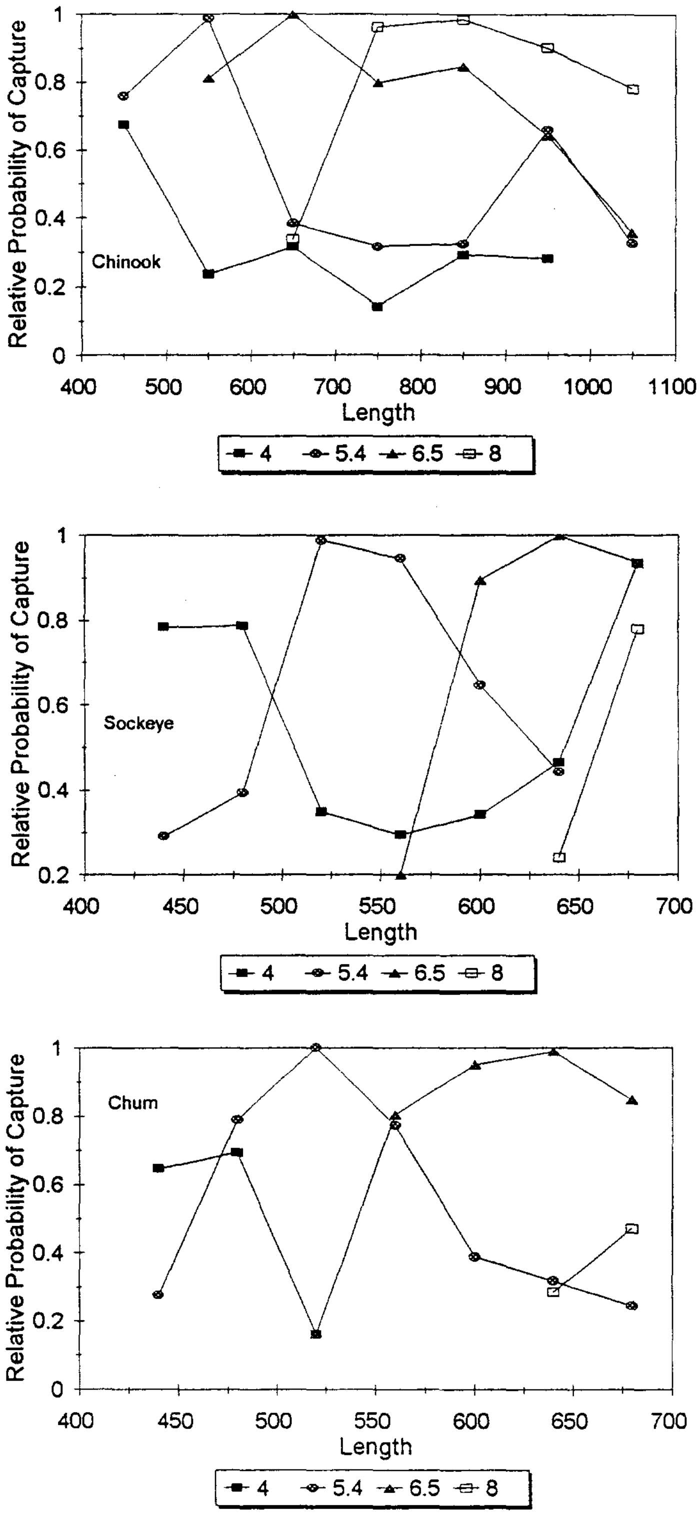


Figure 3. Net selectivity curves for gillnet mesh sizes (in) used for species apportionment for chinook, sockeye, and chum salmon at the Kuskokwim River sonar project, 1994.

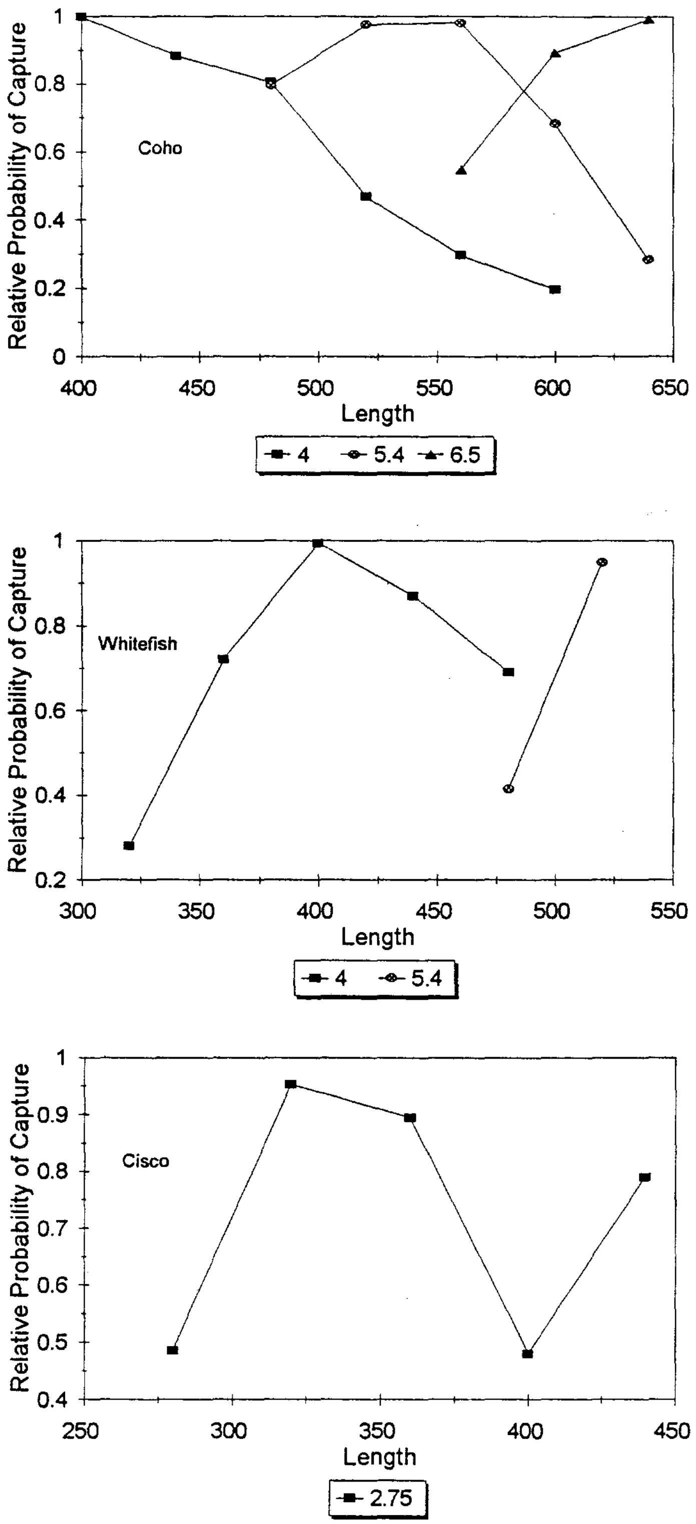


Figure 4. Net selectivity curves for gillnet mesh sizes (in) used for species apportionment of coho salmon, whitefish, and cisco at the Kuskokwim River sonar project, 1994.

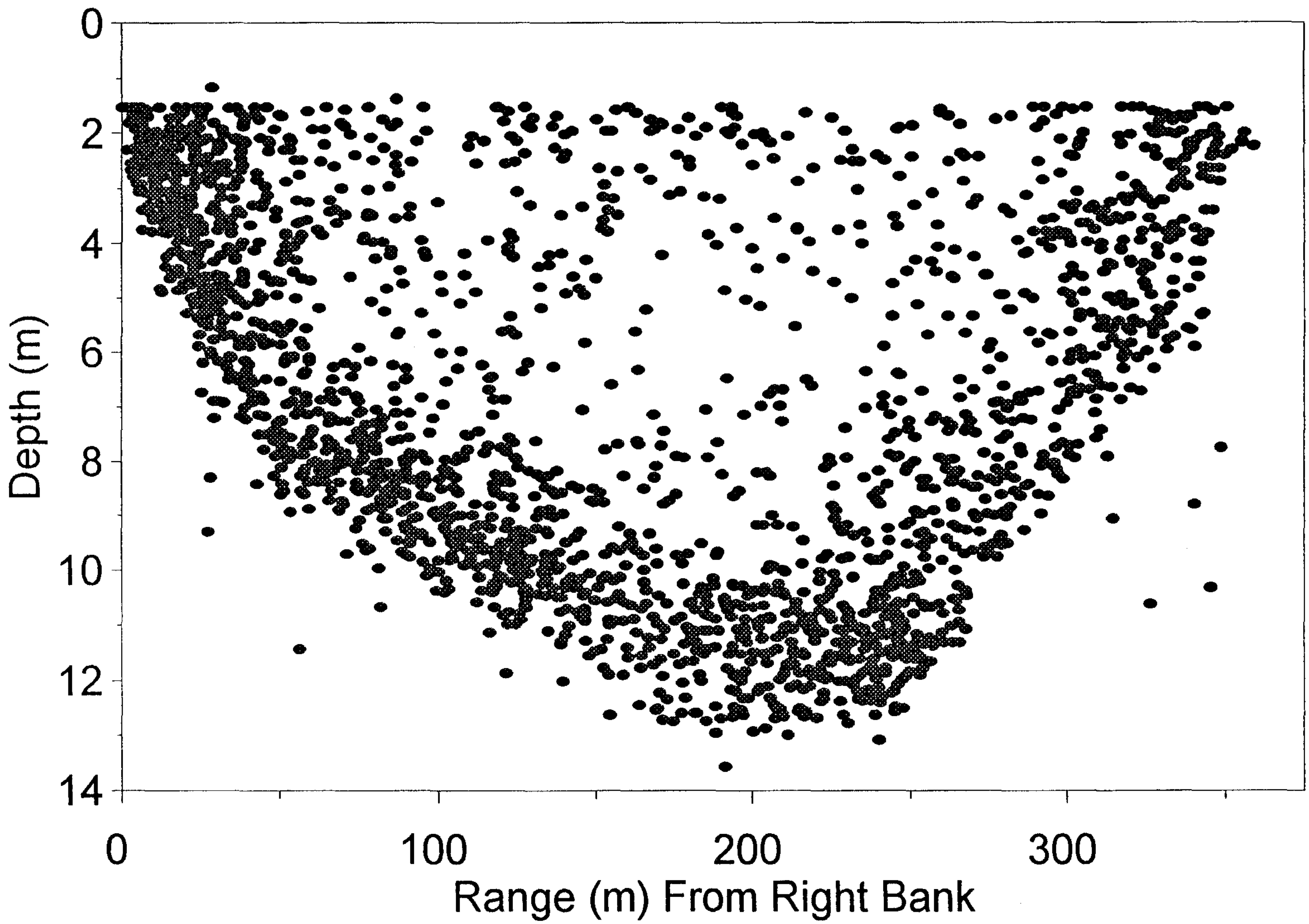


Figure 5. Cross-sectional distribution of fish detected by down-looking sonar on the Kuskokwim River sonar project, 3 June-14 August, 1994. Not adjusted for varying probability of detection with depth.


Figure 6. Pattern of fish passage at range from side-looking and down-looking sonar, Kuskokwim River sonar project, 1994. Down-looking passage is the mean number of fish detected, expanded for variable probability of detection with depth. Side-looking passage is the mean number of fish detected, expanded for time not sampled.

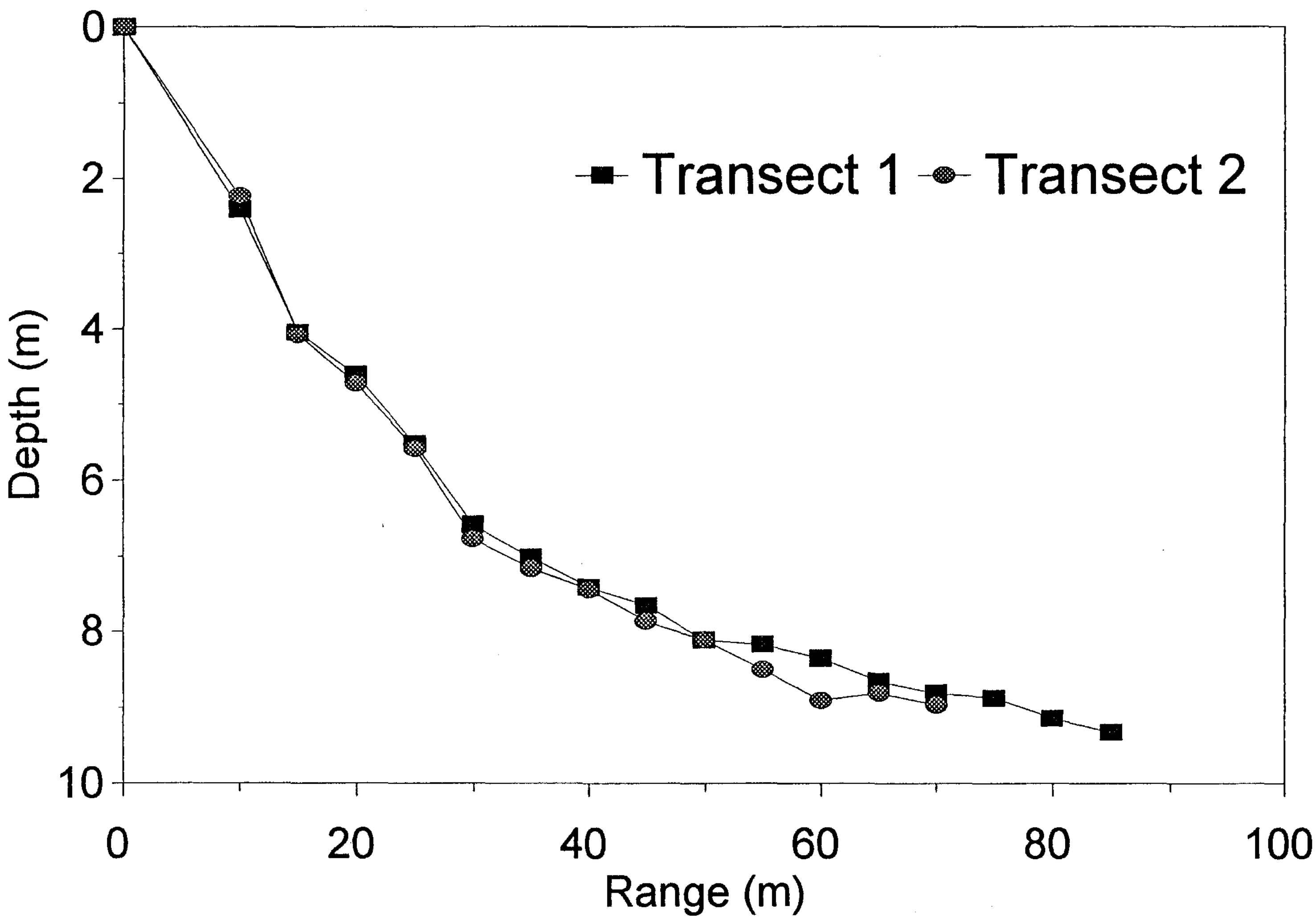


Figure 7. Bottom slope of right bank nearshore from two transects.

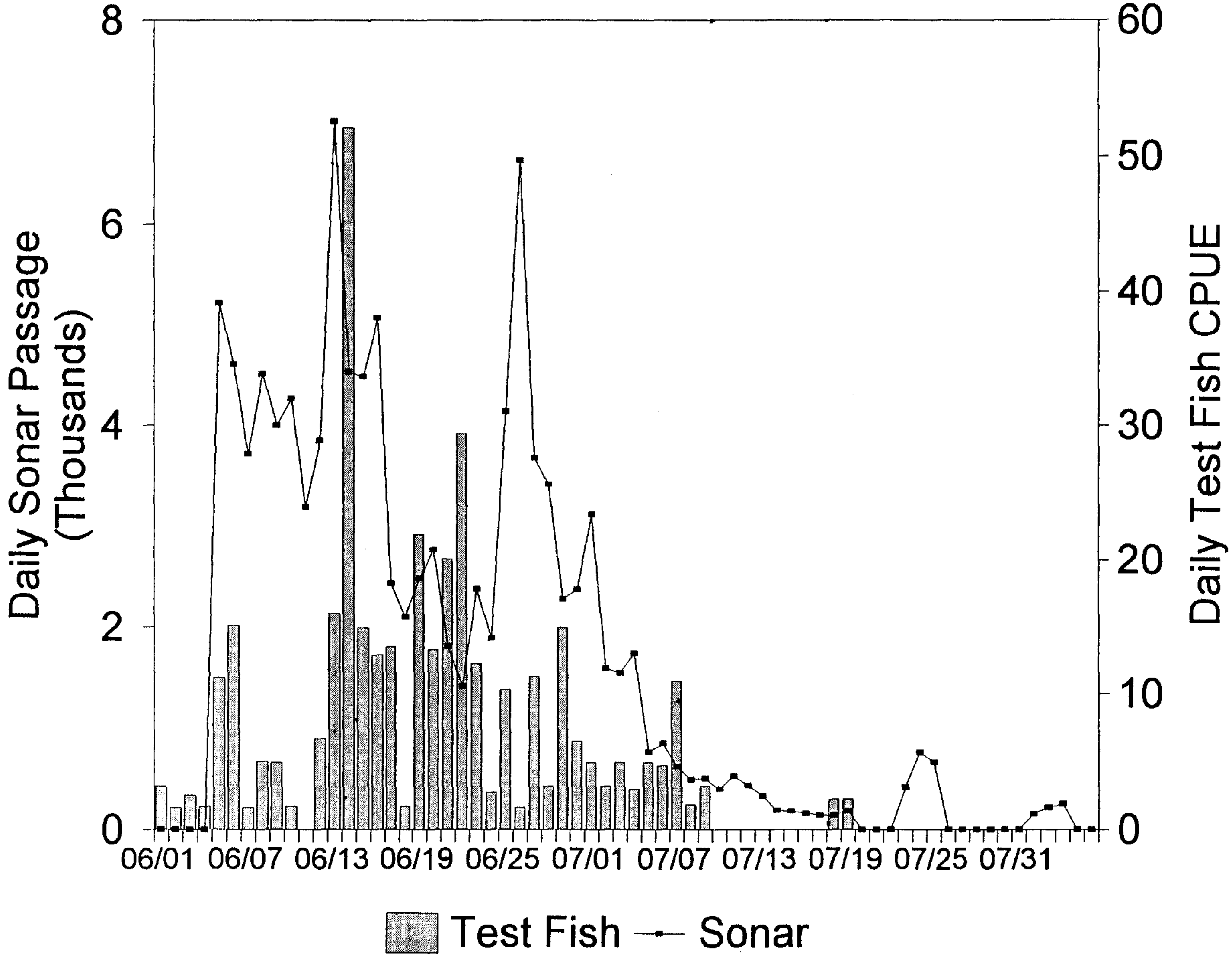


Figure 8. Daily chinook salmon passage as estimated by the Kuskokwim River sonar project and daily chinook salmon CPUE in the Bethel test fishery, 1994.

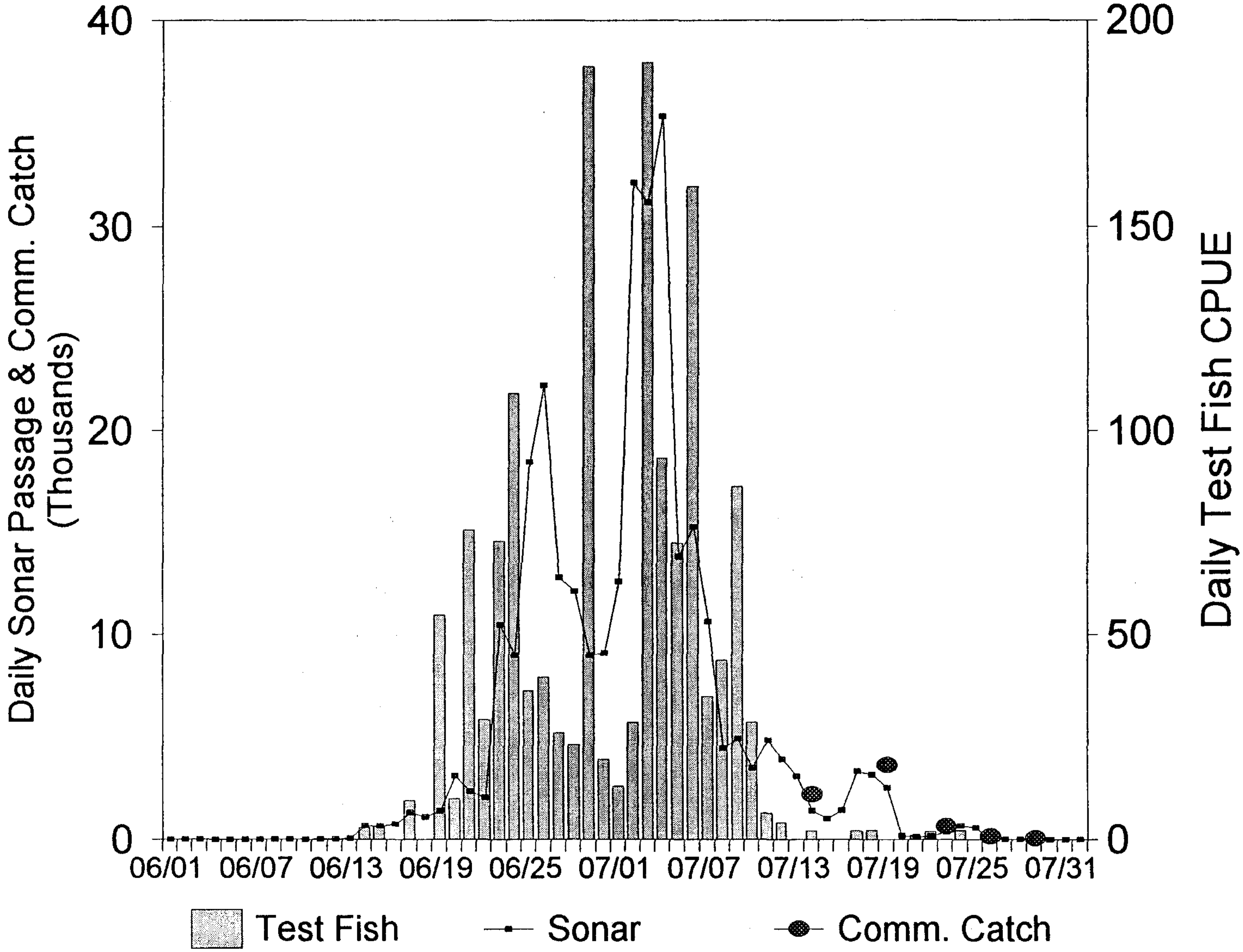


Figure 9. Daily sockeye salmon passage as estimated by the Kuskokwim River sonar project, daily sockeye salmon CPUE in the Bethel test fishery, and commercial sockeye salmon catch upriver from Bethel, 1994.

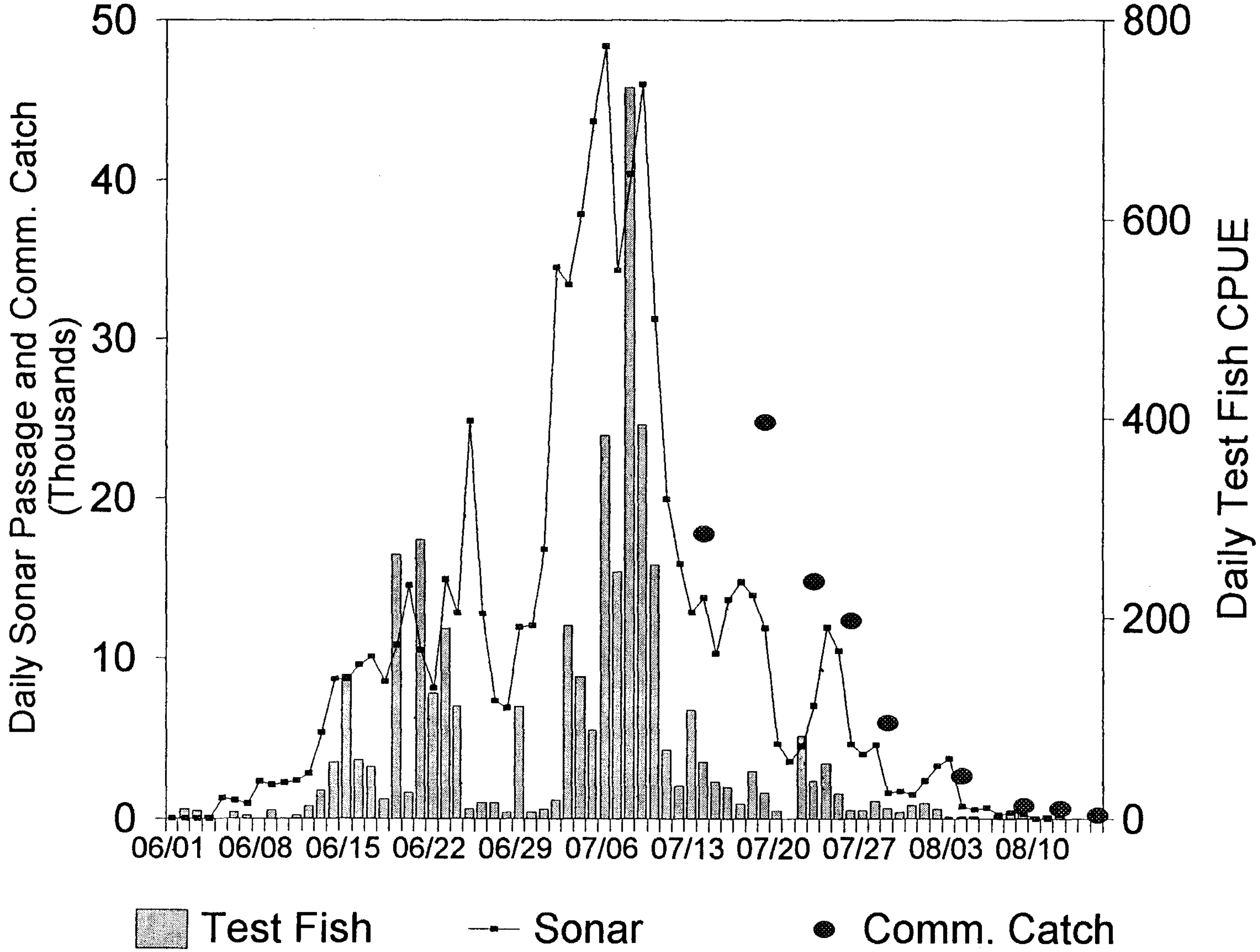


Figure 10. Daily chum salmon passage as estimated by the Kuskokwim River sonar project, daily chum salmon CPUE in the Bethel test fishery, and commercial chum salmon catch upriver from Bethel, 1994.

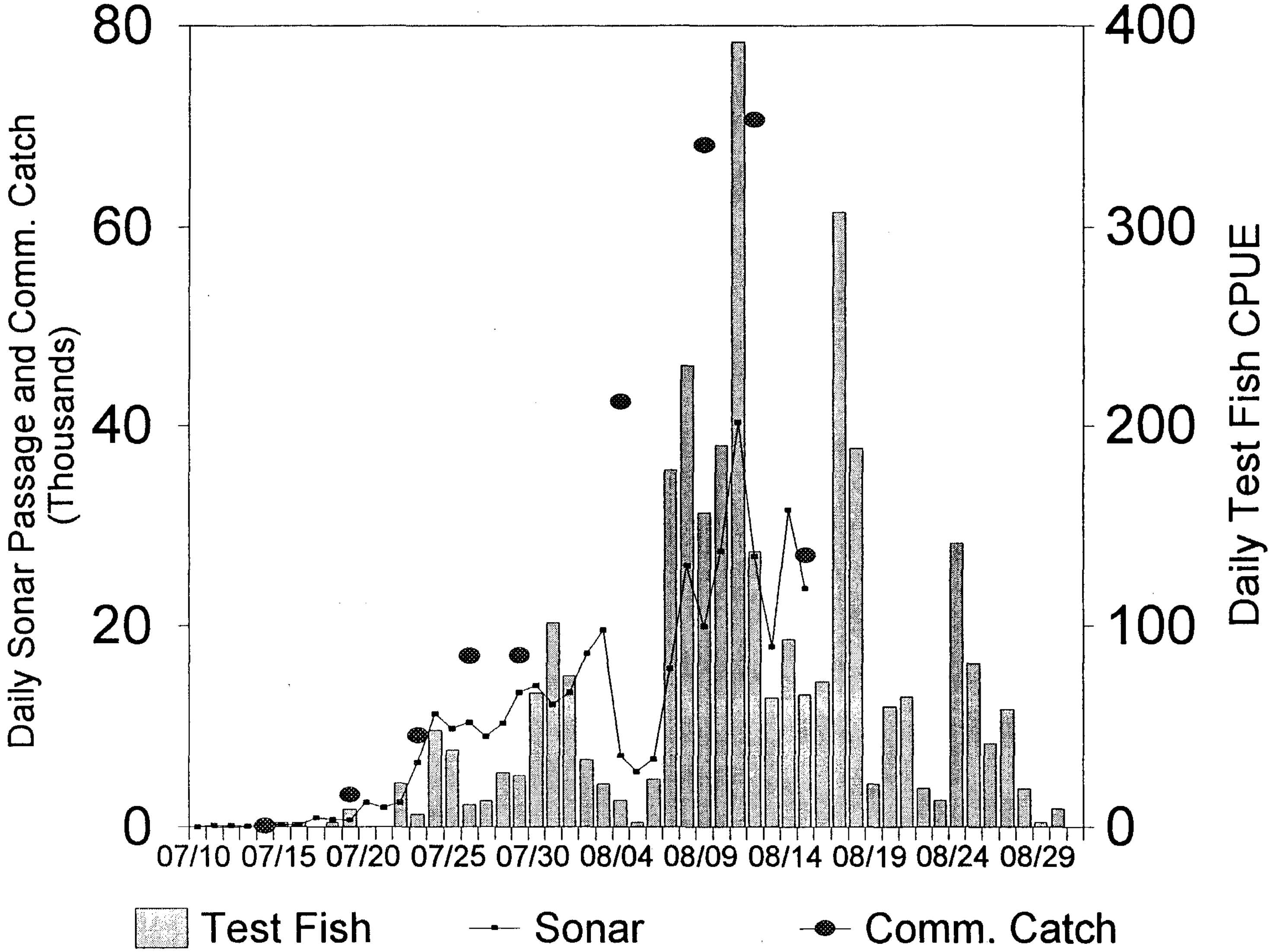


Figure 11. Daily coho salmon passage as estimated by the Kuskokwim River sonar project, daily coho salmon CPUE in the Bethel test fishery, and commercial coho salmon catch upriver from Bethel, 1994.

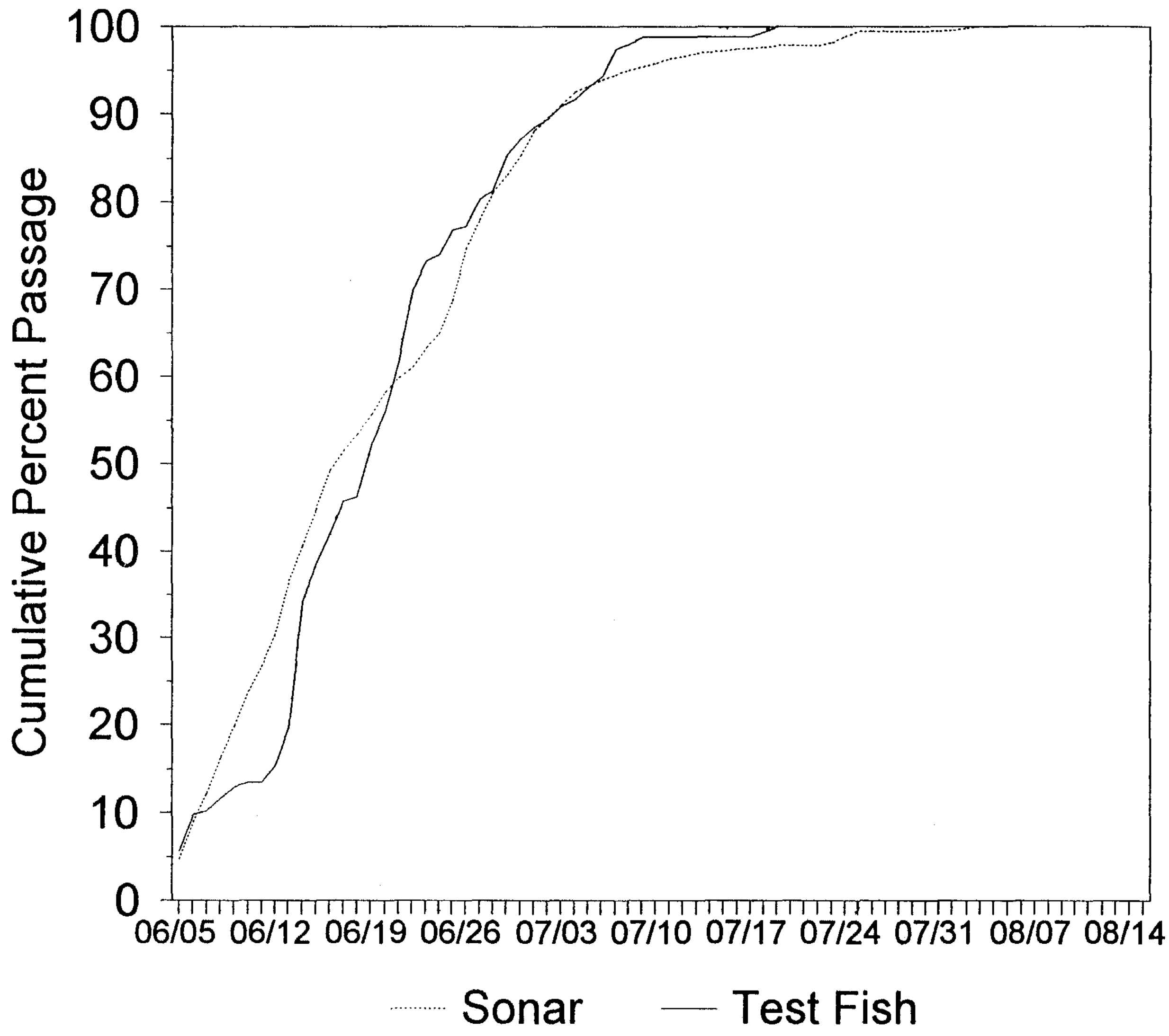


Figure 12. Cumulative percent chinook salmon passage as estimated by the Kuskokwim River sonar project and cumulative percent chinook salmon CPUE in the Bethel test fishery, 1994.

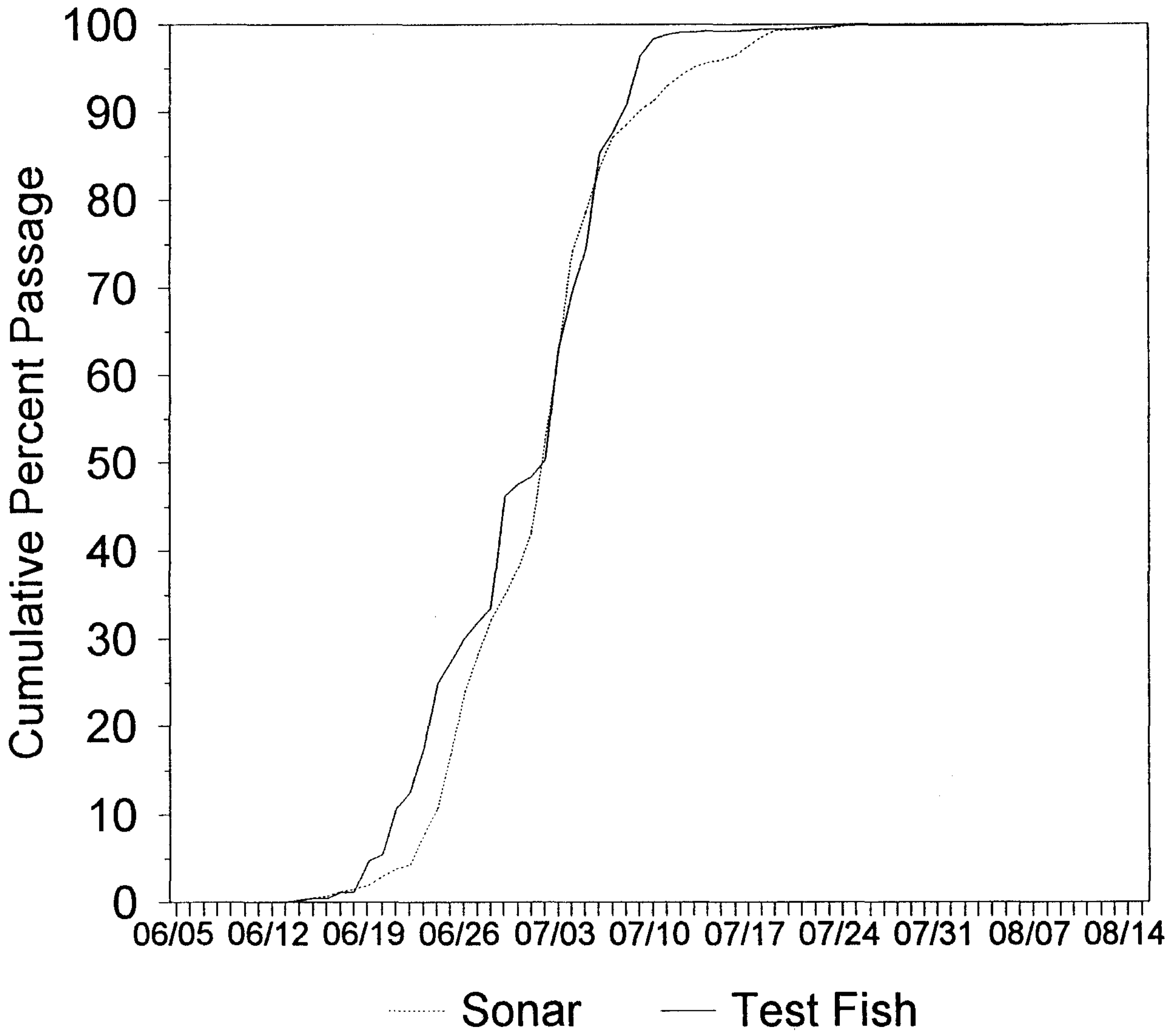


Figure 13. Cumulative percent sockeye salmon passage as estimated by the Kuskokwim River sonar project and cumulative percent sockeye salmon CPUE in the Bethel test fishery, 1994.

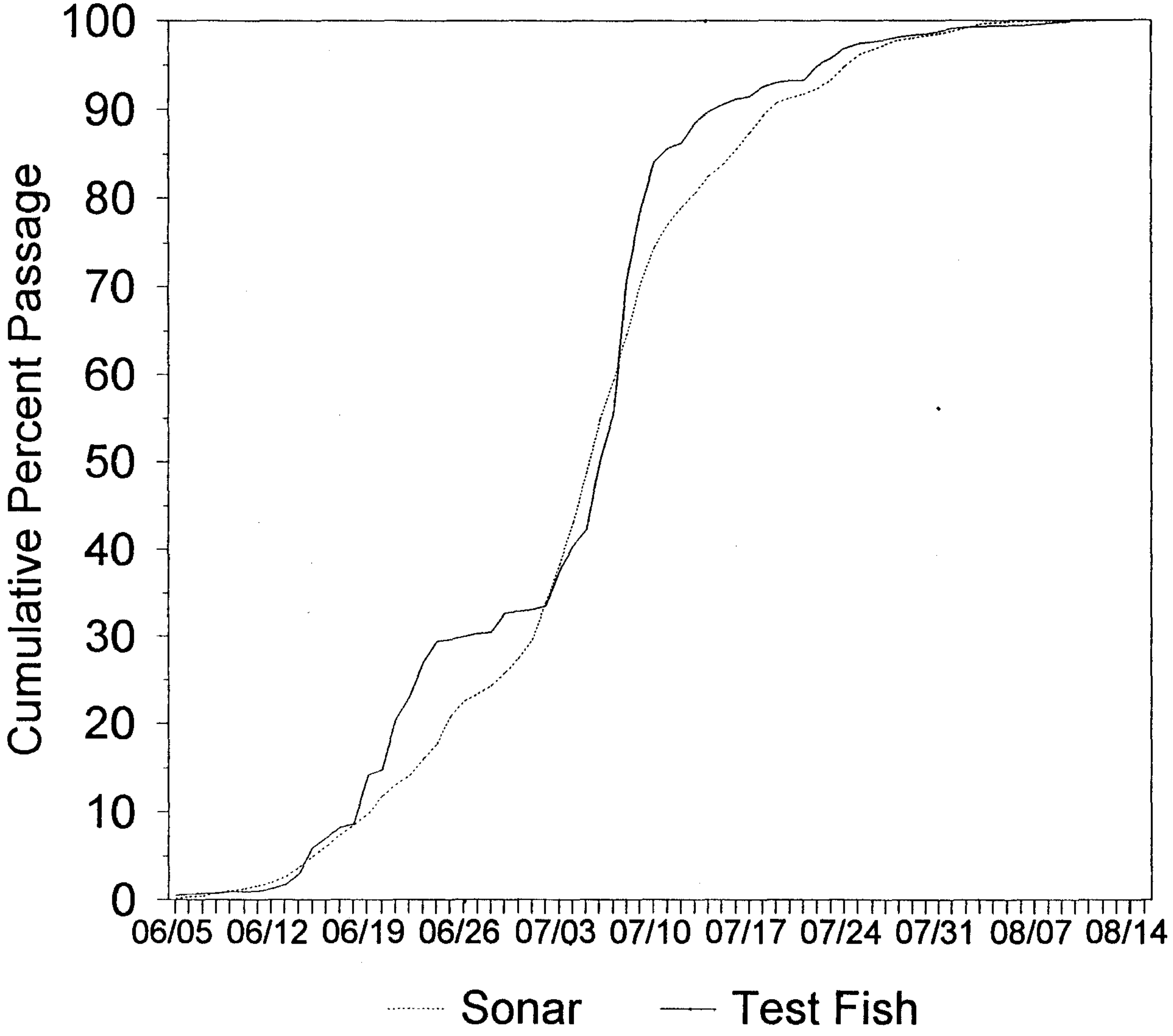


Figure 14. Cumulative percent chum salmon passage as estimated by the Kuskokwim River sonar project and cumulative percent chum salmon CPUE in the Bethel test fishery, 1994.

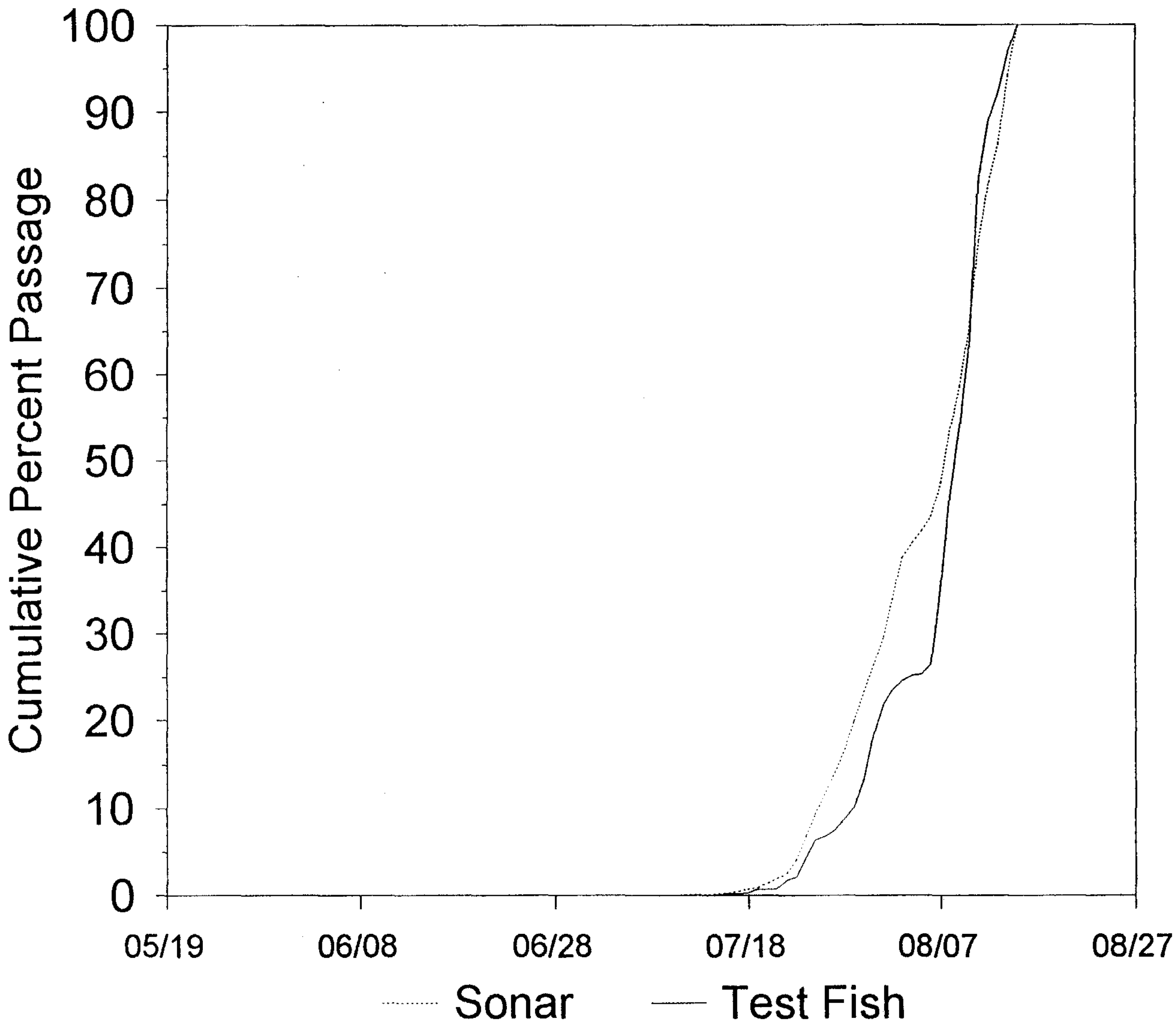


Figure 15. Cumulative percent coho salmon passage as estimated by the Kuskokwim River sonar project and cumulative percent chinook salmon CPUE in the Bethel test fishery, 1994.

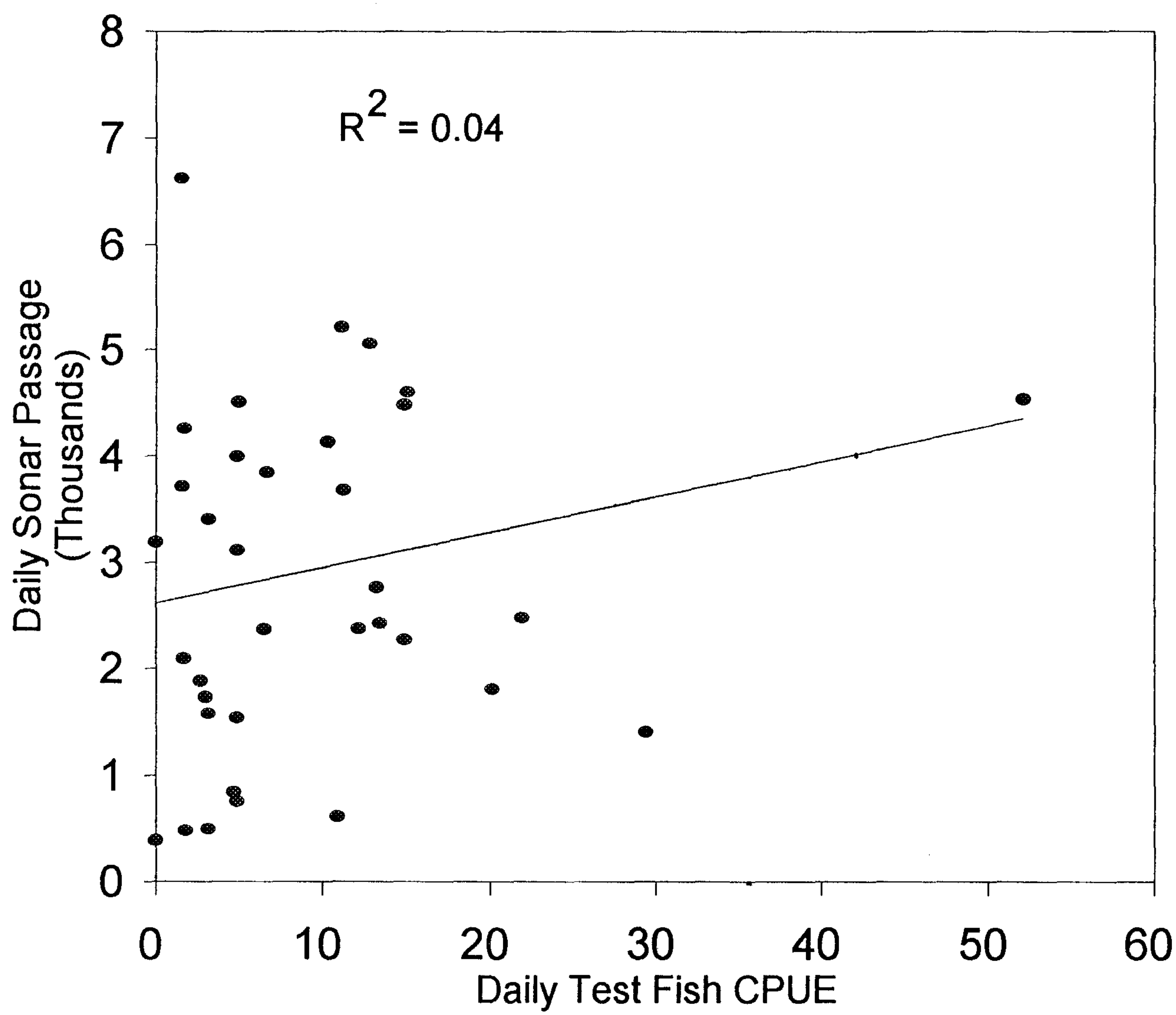


Figure 16. Correlation of daily chinook salmon CPUE in the Bethel test fishery and daily chinook salmon passage as estimated by the Kuskokwim River sonar project, 1994.

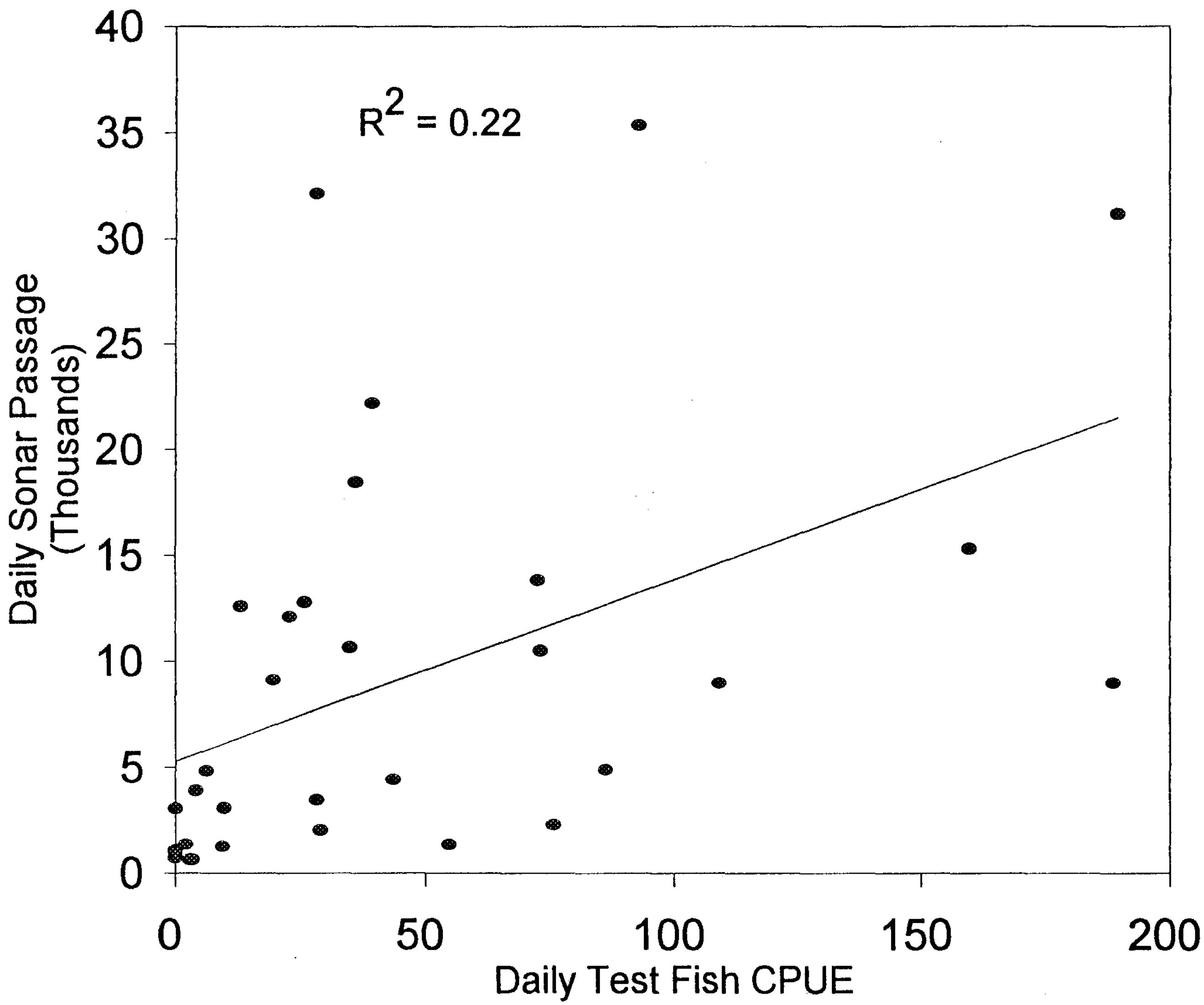


Figure 17. Correlation of daily sockeye salmon CPUE in the Bethel test fishery and daily sockeye salmon passage as estimated by the Kuskokwim River sonar project, 1994.

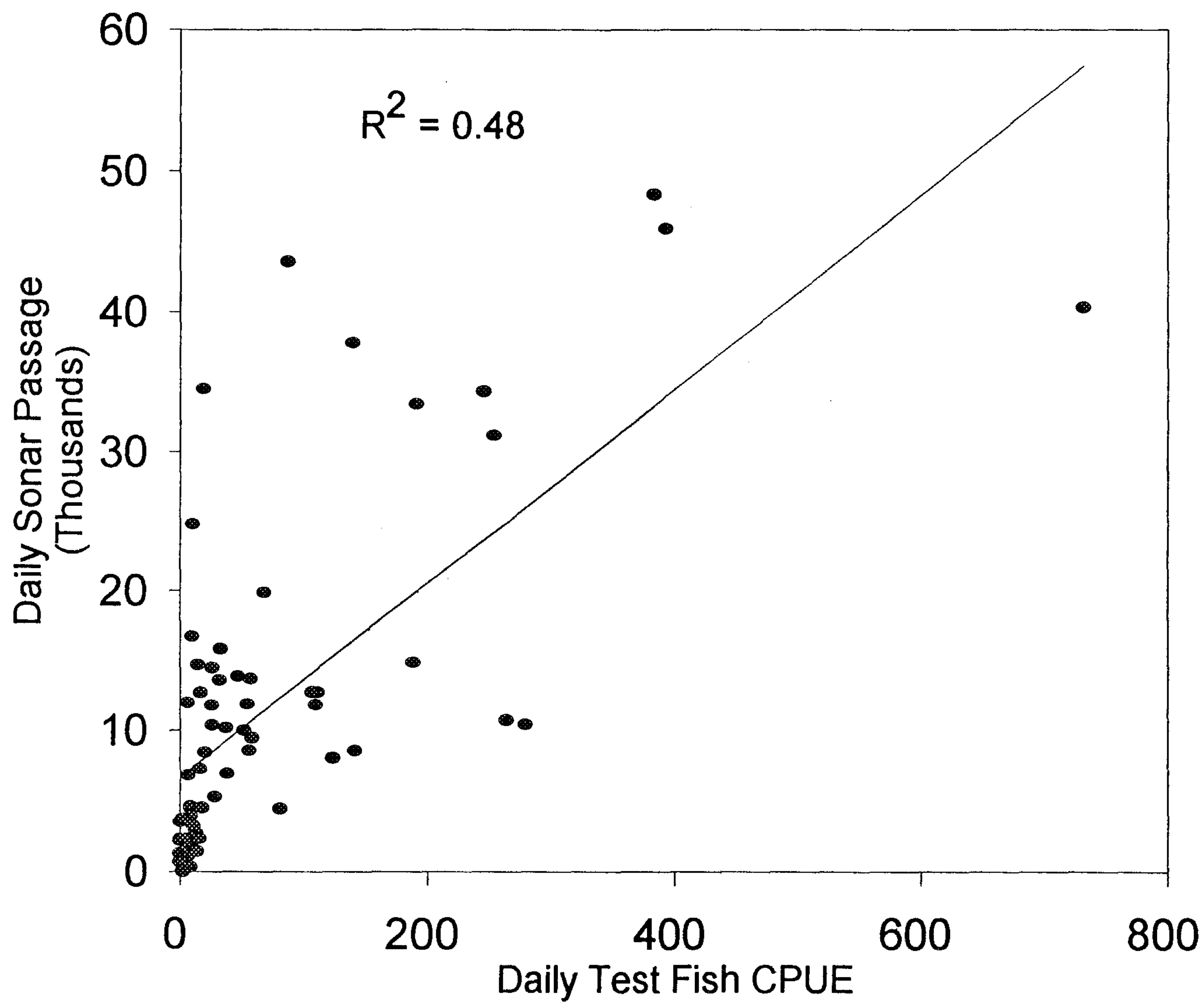


Figure 18. Correlation of daily chum salmon CPUE in the Bethel test fishery and daily chum salmon passage as estimated by the Kuskokwim River sonar project, 1994.

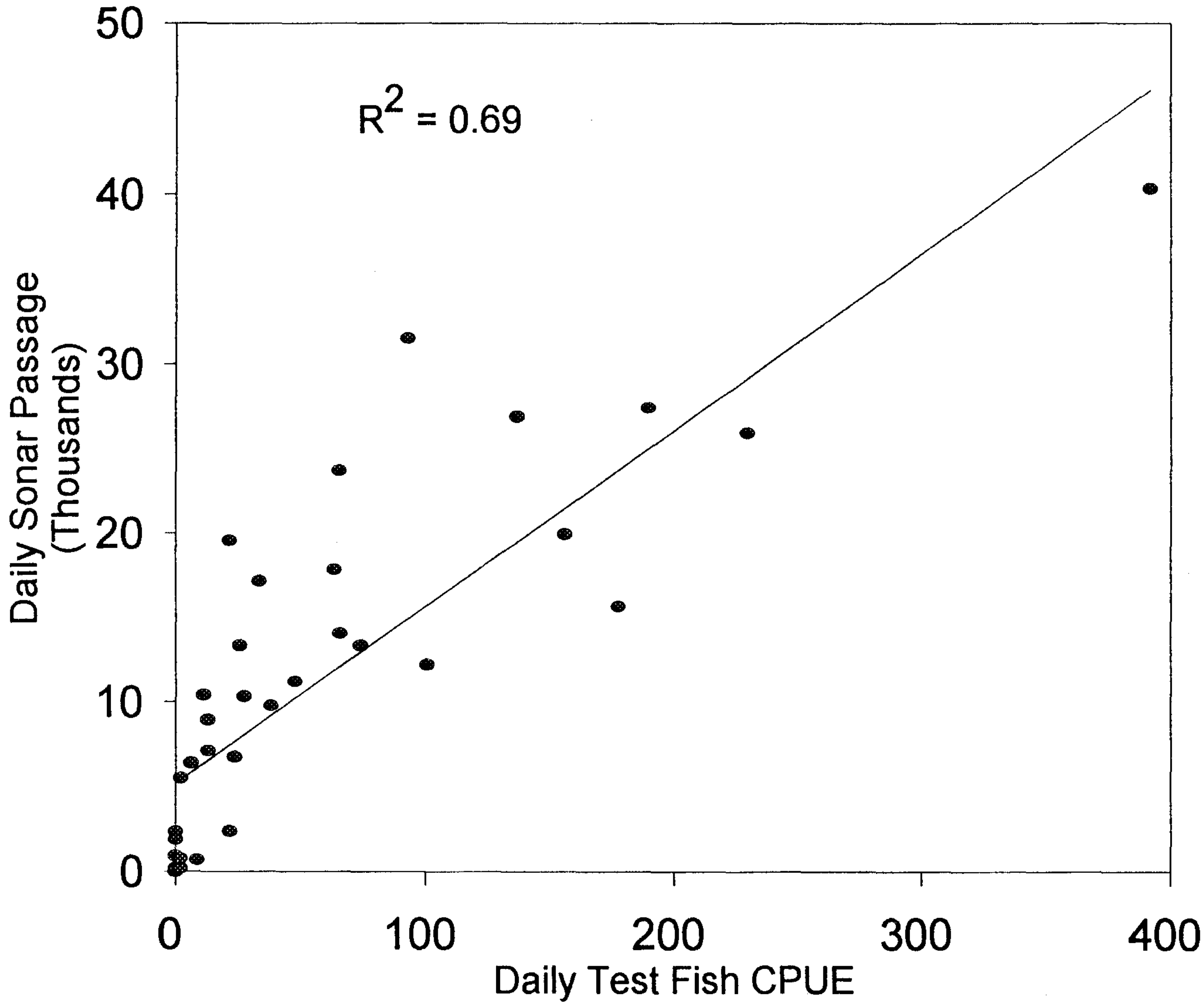


Figure 19. Correlation of daily coho salmon CPUE in the Bethel test fishery and daily coho salmon passage as estimated by the Kuskokwim River sonar project, 1994.

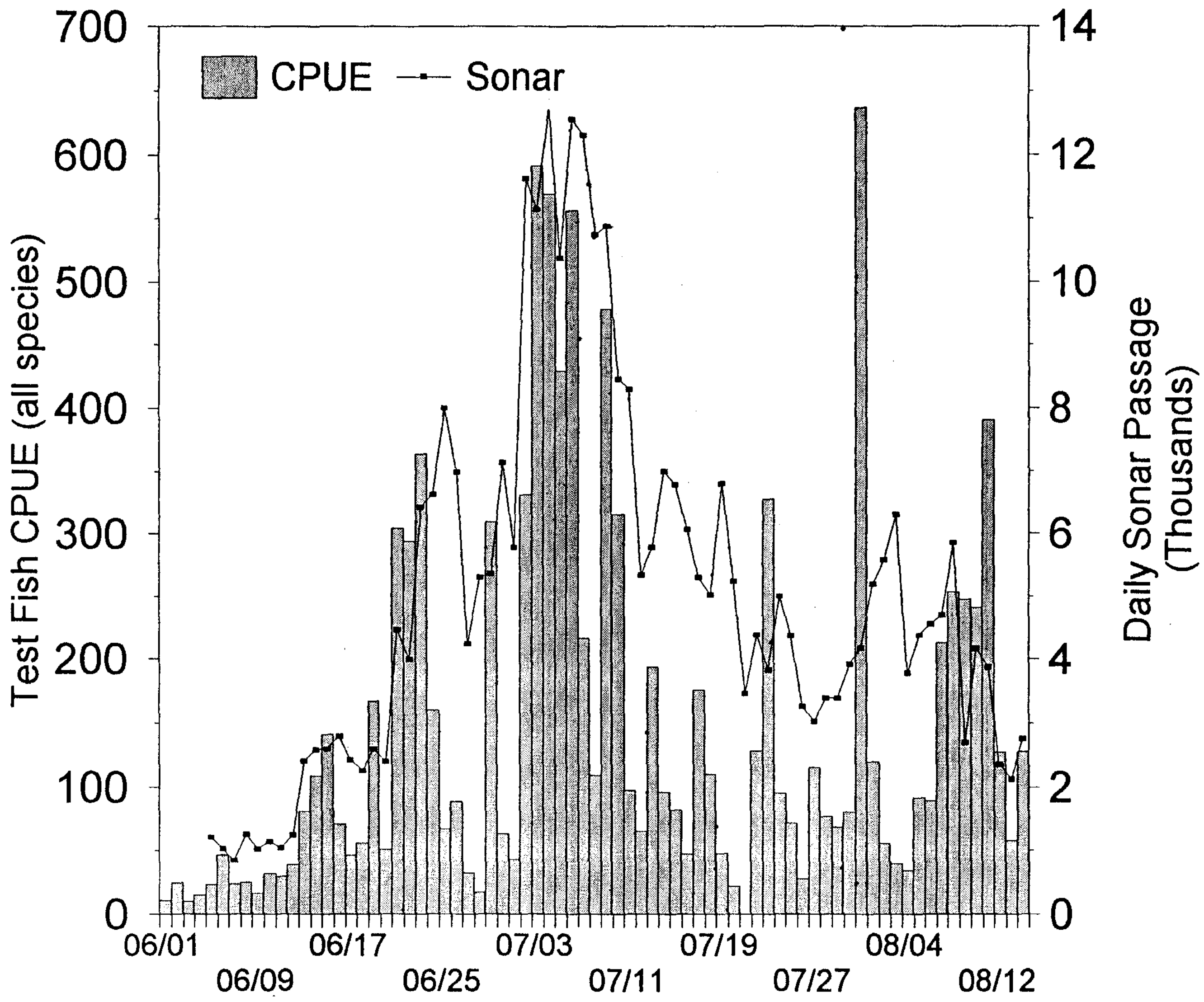


Figure 20. Left bank daily total sonar passage as estimated by the Kuskokwim River sonar project and CPUE (all species) from the Bethel test fishery, 1994.Test fish CPUE is adjusted for net selectivity.

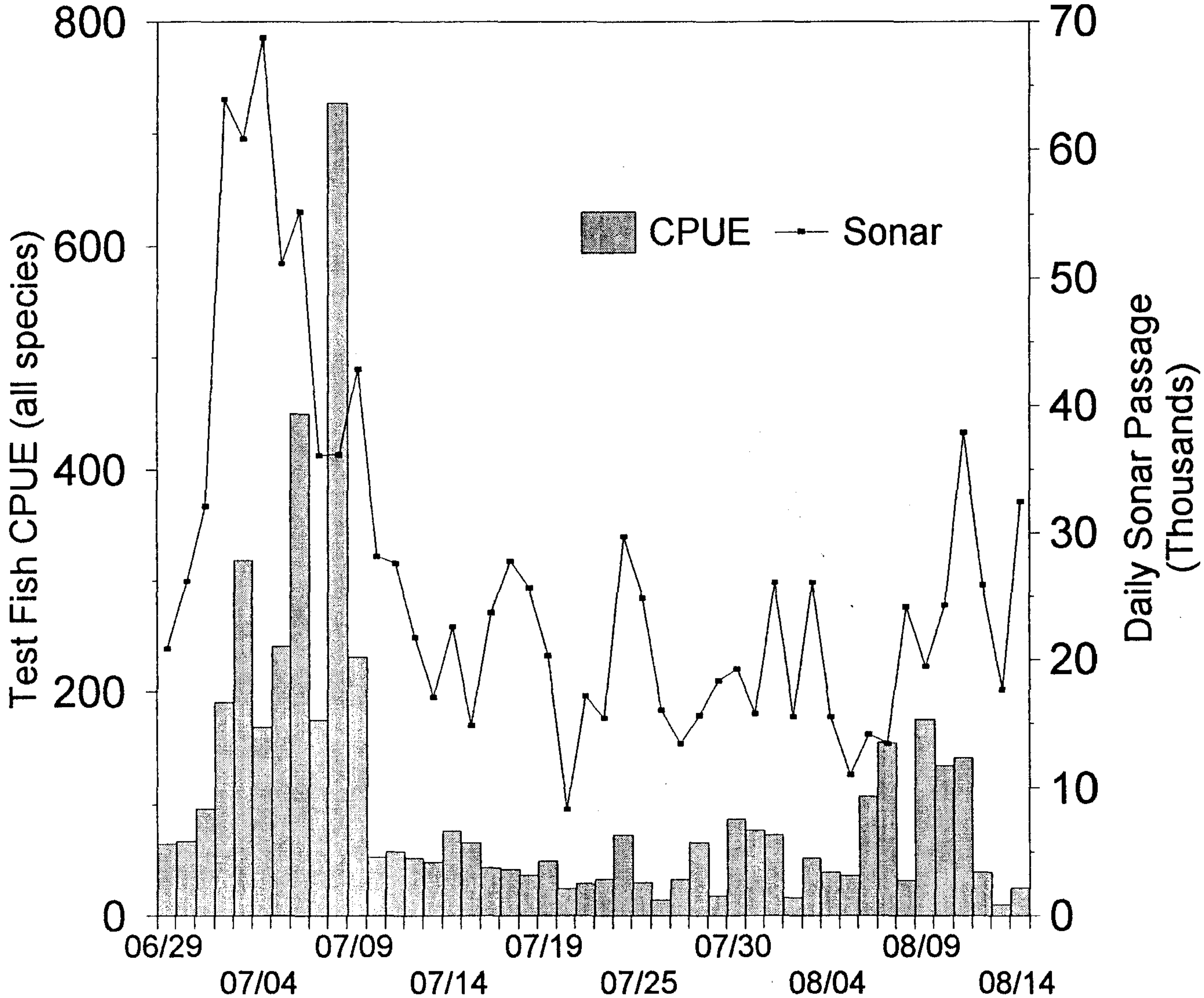


Figure 21. Pooled total sonar passage as estimated by the Kuskokwim River sonar project for strata two and three, and pooled daily CPUE (all species) from the Bethel test fishery at stations two and three, 1994. Test fish CPUE is adjusted for net selectivity.

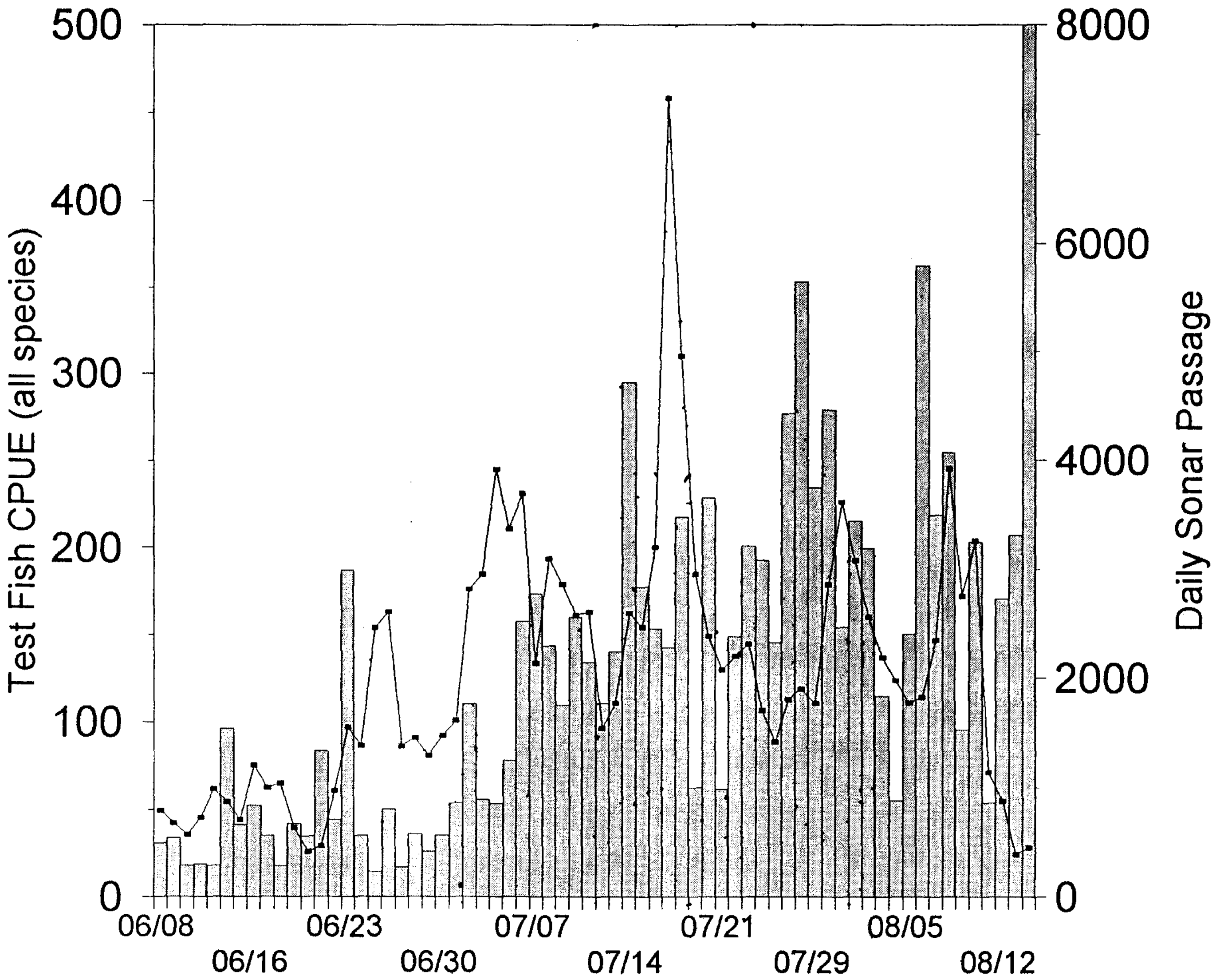


Figure 22. Daily sonar passage as estimated by the Kuskokwim River sonar project in the right bank nearshore stratum and set gillnet CPUE (all species) from the Bethel test fishery, 1994. Test fish CPUE is adjusted for net selectivity.

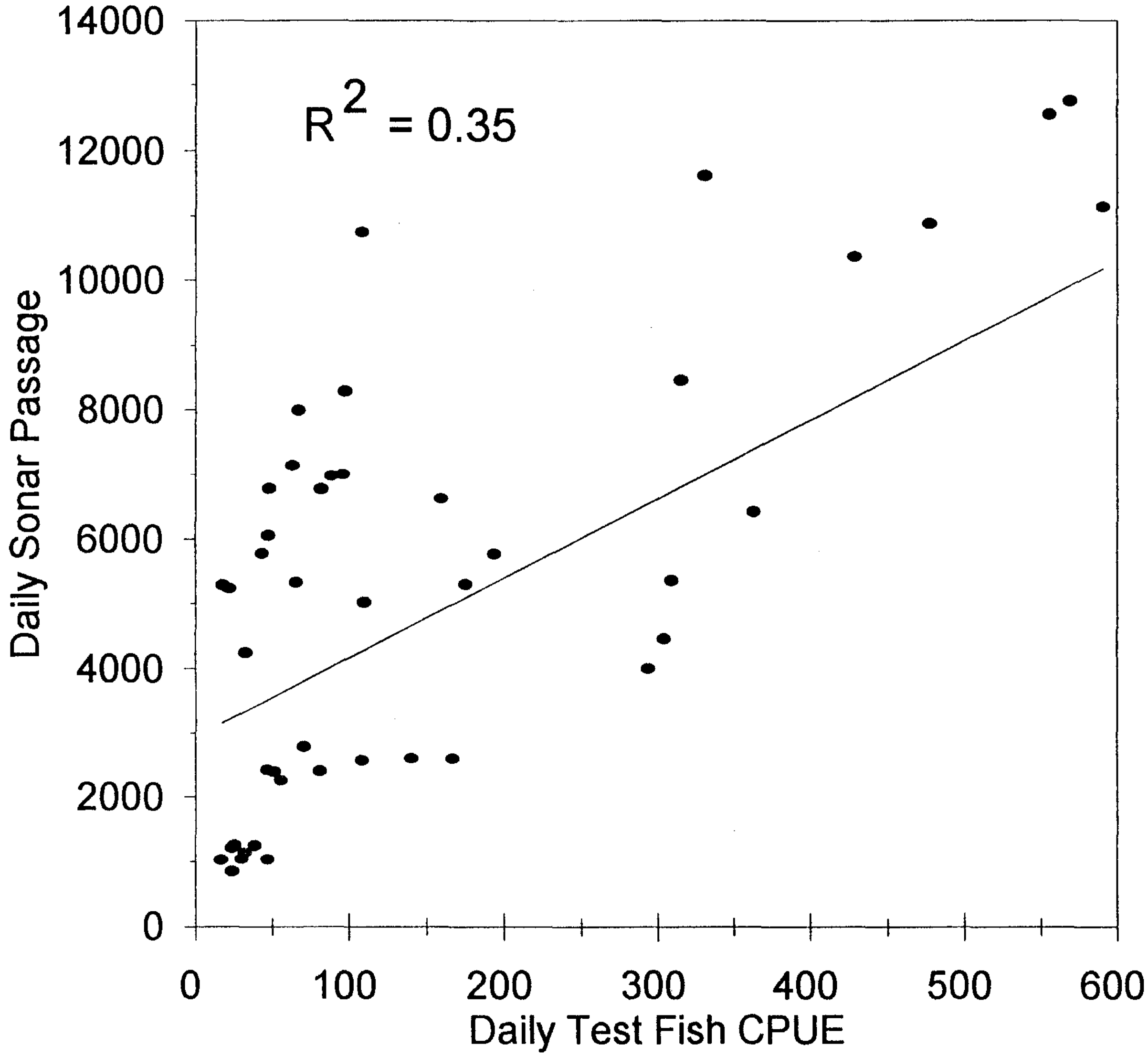


Figure 23. Correlation of daily left bank sonar passage as estimated by the Kuskokwim River sonar project and daily CPUE (all species) from the Bethel test fishery, 1994. Test fish CPUE is adjusted for net selectivity.

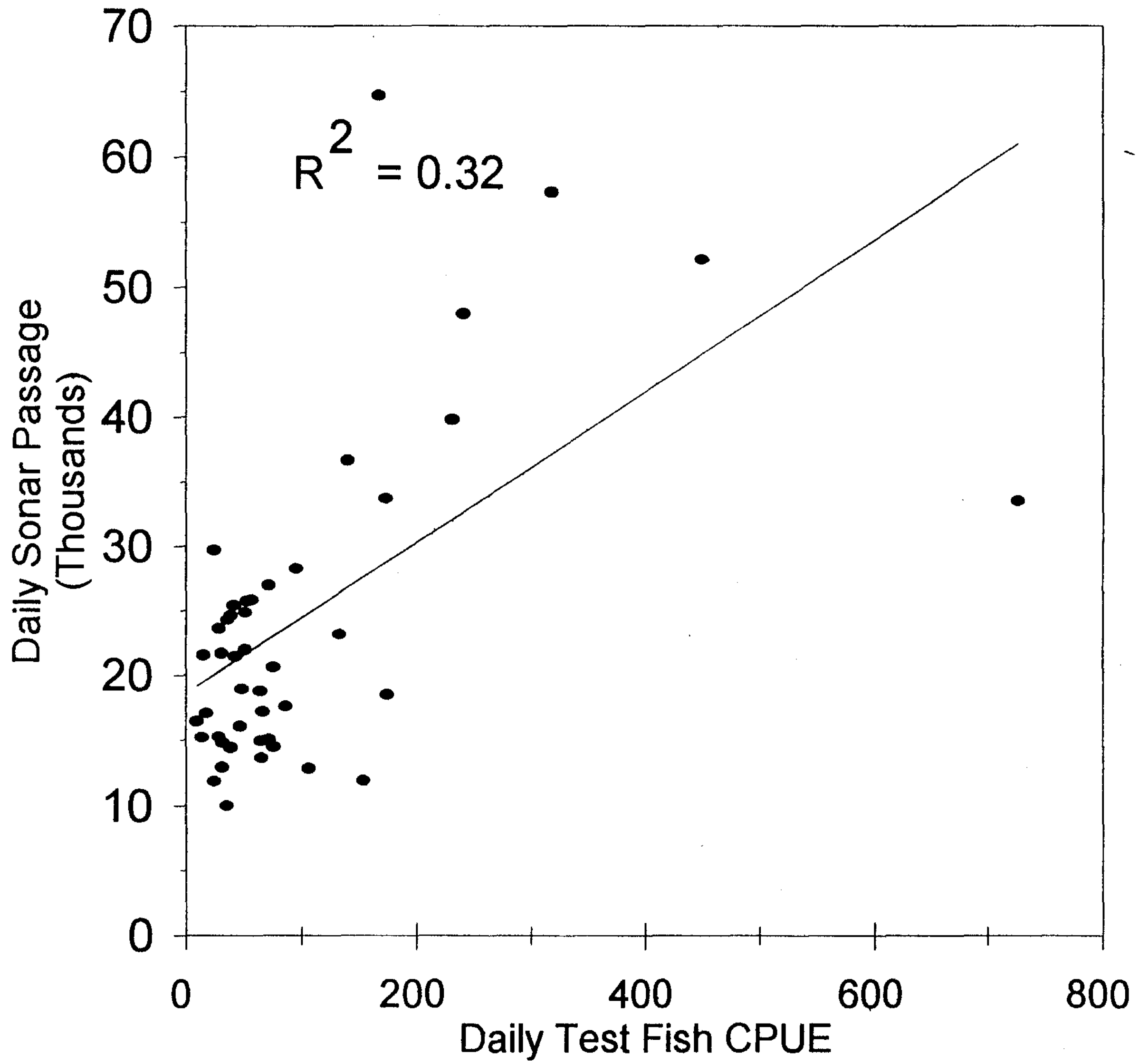


Figure 24. Correlation of pooled daily sonar passage as estimated by the Kuskokwim River sonar project in strata two and three, and pooled daily CPUE (all species) from the Bethel test fishery at stations two and three, 1994. Test fish CPUE is adjusted for net selectivity.

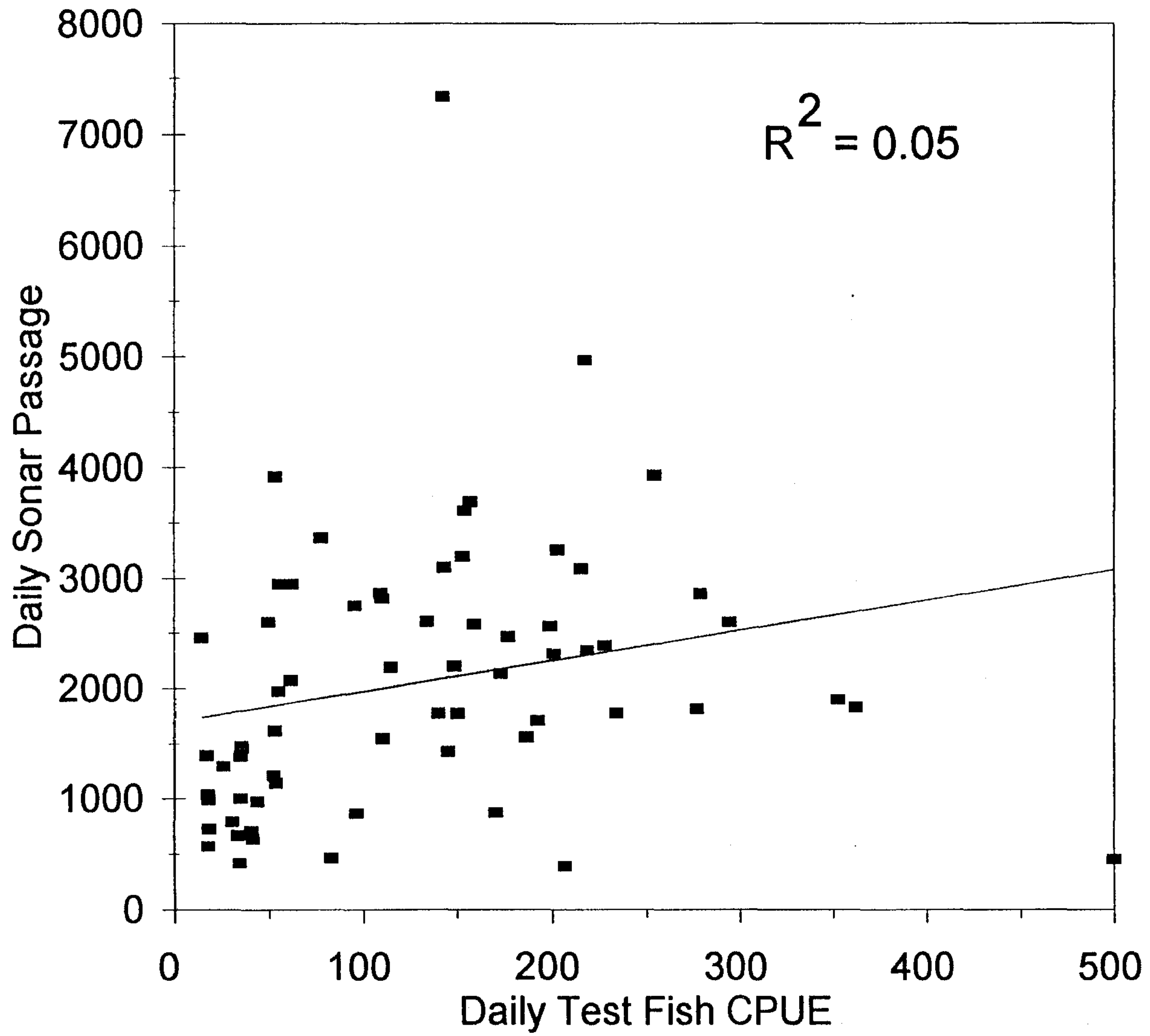


Figure 25. Correlation of daily right bank nearshore sonar passage as estimated by the Kuskokwim River sonar project and daily set gillnet CPUE (all species) from the Bethel test fishery, 1994. Test fish CPUE is adjusted for net selectivity.

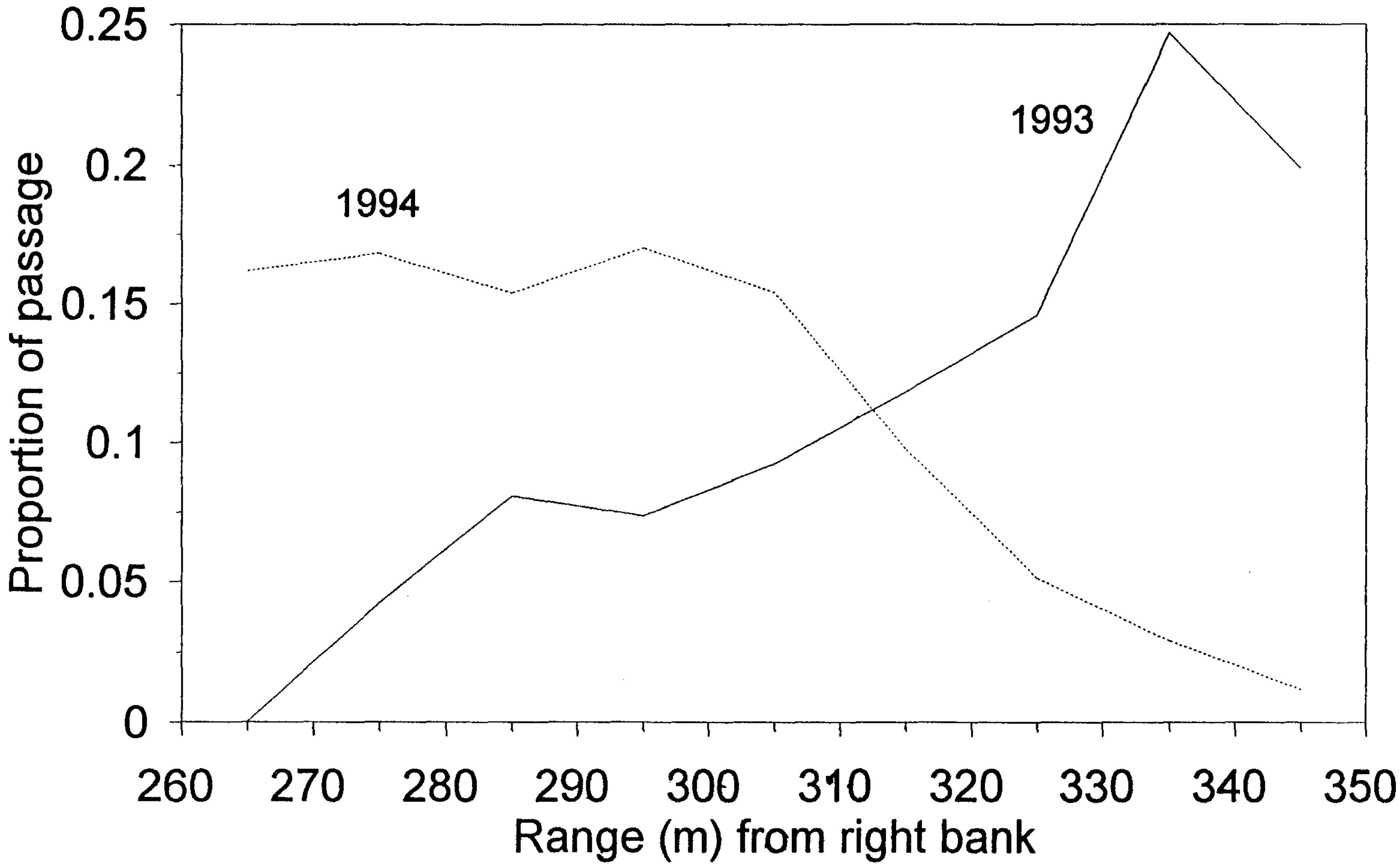


Figure 26. Proportion of passage at range as estimated by side-looking sonar (all species) on the left bank, Kuskokwim River sonar project, 1993 and 1994.

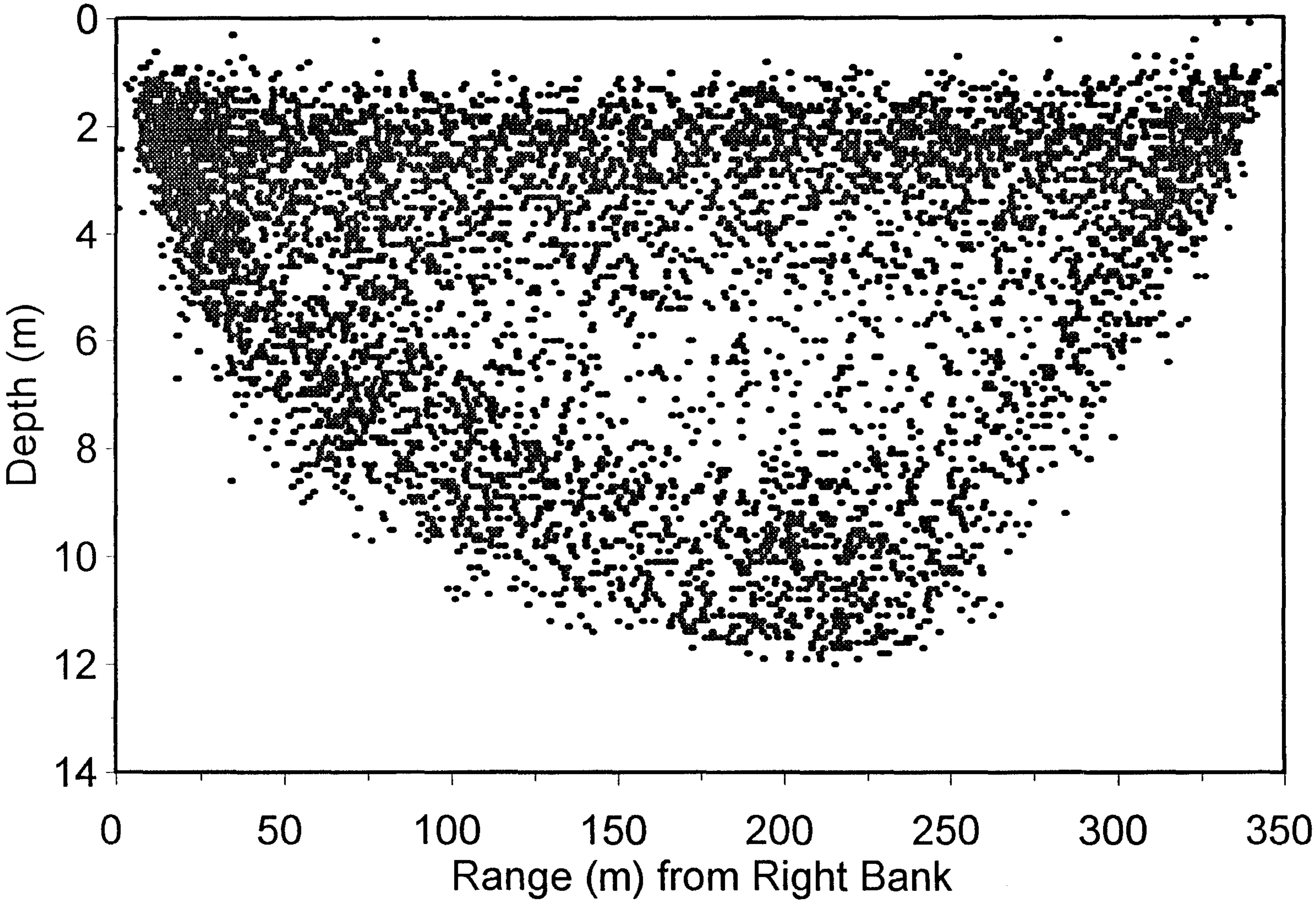


Figure 27. Cross-sectional distribution of fish from down-looking sonar transects (unadjusted for variable probability of detection with depth), Kuskokwim River sonar project, 1993.

Appendix A.1 SAS 6.0 code (BTF94.SAS) used to estimate species proportions and passage by species.

```
*BTF94.SAS: USES BETHEL TESTFISH DATA (DRIFT AND SETNETS) TO APPORTION
 PASSAGE ESTIMATES FROM 1994 KUSKOKWIM SONAR;

*SETNET CATCHES ARE NOT ADJUSTED FOR NET SELECTIVITY;

*BEFORE 29 JUNE STRATIFICATION IS AS FOLLOWS:

 SONAR PASSAGE ESTIMATES                    TESTFISH SPP PROPORTIONS

 RNEAR = 0-40 m                       R BANK SETNETS
 ROFF = 40-180 m                      STATION 3 DRIFTS
 OUT = 180-275 m (the unensonified zone)       STATION 2 DRIFTS
 LEFT = 275-350 m                     STATION 1 DRIFTS;

*AFTER 29 JUNE:

 *SONAR PASSAGE ESTIMATES FROM ROFF AND OUT ARE SUMMED AND
 POOLED TESTFISH DATA FROM STATIONS 2  AND 3 ARE USED TO ESTIMATE SPECIES
 PROPORTIONS FOR THE NEW STRATUM;

 *DEEP 5.375" NETS WERE DRIFTED AT STATION 2.  NET DEPTH IS RECORDED IN FEET AND
 NUMBER OF 14 FOOT DEEP PANELS IS CALCULATED.  NET DEPTH IS ACCOUNTED FOR WHEN
 CALCULATING EFFORT;

 *DATA FROM DEEP NETS ARE IGNORED WHEN CALCULATING HISTORIC BTF TESTNET STATISTICS;
 *DATA FROM SHALLOW 5.375" NETS AT STATION 2 ARE IGNORED FOR PURPOSES OF SPECIES
  APPORTIONMENT.  DATA FROM SHALLOW 4" NETS AT STATION 2 ARE IGNORED ON AND AFTER
  08 JULY (WHEN DEEP 4" NET WAS AVAILABLE) FOR SPECIES APPORTIONMENT;

 *ONLY DATA FROM 5.375" NETS (AND 4" NETS ON AND AFTER 08 JULY) ARE USED TO
  CALCULATE CHUM SALMON CPUE FOR SPECIES APPORTIONMENT.  TO USE OTHER MESHES WOULD
  DILUTE CHUM CATCHES AND BIAS THE APPORTIONMENT;

 *MESHES USED TO APPORTION SOCKEYE HAVE NOT CHANGED, SINCE THERE IS NO EVIDENCE THAT
  SOCKEYE, LIKE CHUM, ARE MORE ABUNDANT NEAR THE BOTTOM OF THE RIVER;

title1 'Kuskokwim River Sonar Species Apportionment Program:  BTF94.SAS';
options linesize=120 pagesize=47;

data snrwide;
  infile 'd:\runsasw\snrcnt94.btf' firstobs=4;
  input report day month year rnear roff left out;
  date =mdy(month,day,year);
  IF DATE GE '29JUN94'D THEN DO;
    DEEP=ROFF + OUT;
    ROFF=.; OUT=.;
    END;
  drop year month day;
  format date date7.;
  label rnear='RIGHT BANK NEARSHORE' roff='RIGHT BANK OFFSHORE'
        left='LEFT BANK PASSAGE' out='OUT OF BEAM'
        deep = 'RB OFFSH + UNENSONIFIED';
  run;


title2 'ESTIMATED FISH PASSAGE, BY DAY';
proc print label data=snrwide;
  var report date;
```

```
 sum rnear roff out deep left;
 run;


proc transpose data=snrwide out=snrcnts;
 by report date; var rnear roff out deep left;
 run;

data snrcnts; set snrcnts;
 rename col1=psg;
 if _name_ = 'RNEAR' then station = 4;
 if _name_ = 'ROFF' then station = 3;
 if _name_ = 'OUT' then station = 2;
 if _name_ = 'DEEP' then station = 2.5;
 if _name_ = 'LEFT'  then station = 1;
 run;

proc summary data=snrcnts nway;
 class report station;
 var psg;
 output out=reptcnts sum=;
 run;


*BEGIN TESTFISH DATA PROCESSING;
*PANELS = NUMBER OF PANELS DEEP;
*PANEL = WHICH PANEL FISH IS LOCATED IN;
data testfish;
 length species $ 8;
 infile 'd:\runsasw\tfishdat.del' delimiter=',';
 informat date mmddyy. startout fullout startin fullin time8.;
 format date date7. startout time5.;
 input METHOD date tide drift station mesh panel spcode length
   SEX $ fathoms startout fullout startin fullin;
 IF METHOD=2 THEN STATION=4;
 IF PANEL=0 THEN PANELS=1;
 ELSE IF PANEL GT 0 THEN PANELS=2;
  if fullout lt (startout-82800) then do;
   fullout=fullout+86400;
   startin=startin+86400;
   fullin=fullin+86400;
   end;
 if startin lt (fullout-82800) then do;
   startin=startin+86400;
   fullin=fullin+86400;
   end;
 if fullin lt (startin-82800) then do;
   fullin=fullin+86400;
   end;
 drifmins = (startin-fullout)/60 + (fullout-startout)/(2*60) +
         (fullin-startin)/(2*60);
 drop fullout startin fullin;
 lclassmp= round(length,40);
 if spcode = 0 or spcode = . then species = 'NONE';
 if spcode = 2 then species = 'SOCKEYE';
 if spcode = 3 then species = 'COHO';
 if spcode = 4 then species = 'PINK';
 if spcode = 5 then species = 'CHUM';
 if spcode = 6 or spcode = 7 then  do;
                  spcode = 7;
```

```
                 species = 'CISCO';
                 end;
 if spcode = 8 or spcode = 9 then do;
                 spcode = 6;
                 species = 'WHITE';
                 end;
 if spcode ge 10 and spcode le 16 then do;
                 spcode = 9;
                 species = 'OTHER';
                 end;
 if spcode = 1 then do;
   if length=0 then lclassmp=0;
   else lclassmp= round(length+50,100)-50;
   if length gt 640 then species = 'LCHINOOK';
   if length le 640 then do;
     spcode = 8; species = 'SCHINOOK'; end;
   end;

 if mesh=2.7   then do;
                 mesh=2.75;
                 meshcode=1;
                 end;
 if mesh=4.0   then meshcode=2;
 if mesh=5.4   then do;
                 mesh=5.375;
                 meshcode=3;
                 end;
 if mesh=6.5   then meshcode=4;
 if mesh=8.0   then meshcode=5;

*USE 5.375 INCH SLOT FOR 5.5 INCH SETNETS FOR NOW;
if method=2 and mesh=5.5 then do;
  meshcode=3;
  mesh=5.375;
  end;
run;

*COUNT THE NUMBER OF FISH OF EACH SPECIES IN EACH DRIFT;
proc sort data=testfish;
  by date tide method drift;
  run;
proc summary data=testfish nway;
  by date tide method drift;
  class mesh station startout species;
  var spcode; id panels fathoms drifmins;
  output out=sppcatch n=sppcatch;
  run;

proc transpose data=sppcatch out=tfsummar;
  var sppcatch; id species;
  by date tide method drift mesh panels station fathoms drifmins startout;
  run;

data spplist;
  lchinook=0; schinook=0; sockeye=0; chum=0; cisco=0;
  pink=0; coho=0; white=0; other=0;
  run;

data tfsummar; set tfsummar(in=a) spplist;
  if a;
```

```
  fathhrs= panels*fathoms*drifmins/60;
  format date date5. startout time5. fathhrs 5.0;
  label panels='PANELS DEEP' fathhrs='FATHOM HOURS' ;
  run;

proc sort data=tfsummar out=print; by date tide method drift; run;

title2 'SUMMARY OF TESTFISH RESULTS, BY DRIFT';
proc print data=print label noobs;
  var date tide method drift startout mesh panels station;
  sum fathhrs lchinook schinook sockeye chum pink coho white cisco other;
  run;

*BEGIN HISTORIC BETHEL TESTFISH DATA PROCESSING;
data historic; set tfsummar(drop=startout pink white other);
  if mesh=5.375 or mesh=8.0;  if method=1;  if panels eq 1;
  if lchinook=. then lchinook=0;  if schinook=. then schinook=0;
  if sockeye=. then sockeye=0;  if chum=. then chum=0;
  if coho=. then coho=0;
  chinook=lchinook+schinook;
  if fathhrs = 0 then do;
    if drift = 0 or station = 8 then put 'Missed Drift:  ' date '  tide: ' tide;
    else put 'Zero Effort  ' date '  tide: ' tide;
    end;
  else do;
    chincpue=100*chinook/fathhrs;
    sockcpue=100*sockeye/fathhrs;
    chumcpue=100*chum/fathhrs;
    cohocpue=100*coho/fathhrs;
    end;

  format chincpue sockcpue chumcpue cohocpue drifmins mesh 5.1 fathoms 3.0;
  label chincpue='CHINOOK CPUE' sockcpue='SOCKEYE CPUE' chumcpue='CHUM CPUE'
       cohocpue='COHO CPUE' chinook='CHINOOK CATCH' sockeye='SOCKEYE CATCH'
       chum='CHUM CATCH' coho='COHO CATCH';
  run;

title2 'CPUE BY DRIFT, 5.375 inch AND 8.0 inch MESH ONLY';
proc print data=historic noobs label;
  var date tide drift station mesh fathoms drifmins chinook chincpue
     sockeye sockcpue chum chumcpue coho cohocpue;
  sum chinook sockeye chum coho;
  run;

proc summary data=historic nway;
  var chinook chincpue;
  class date tide;
  output out=chintide sum(chinook)= mean(chincpue)=;
  run;

data smalmesh; set historic;
  if mesh=5.375;
  run;

proc summary data=smalmesh nway;
  var sockeye sockcpue chum chumcpue coho cohocpue;
  class date tide;
  output out=scctide sum(sockeye chum coho)=
                 mean(sockcpue chumcpue cohocpue)=;
  run;
```

```
data histtide;
  merge chintide scctide;
  by date tide;
  format chincpue sockcpue chumcpue cohocpue 5.1;
  label chincpue='CHINOOK CPUE' sockcpue='SOCKEYE CPUE' chumcpue='CHUM CPUE'
       cohocpue='COHO CPUE' chinook='CHINOOK CATCH' sockeye='SOCKEYE CATCH'
       chum='CHUM CATCH' coho='COHO CATCH';
  run;

title2 'MEAN CPUE BY TIDE';
title3 'chinook 5.4 inch and 8 inch nets; sockeye, chum, and coho 5.4 inch net only';
proc print noobs label data=histtide;
  var date tide chinook chincpue sockeye sockcpue chum chumcpue coho cohocpue;
  sum chinook sockeye chum coho;
  run;

proc summary data=histtide nway;
  class date;  var chincpue sockcpue chumcpue cohocpue;
  output out=histday sum=;
  run;

data histday; set histday;
  format chincpue sockcpue chumcpue cohocpue 5.1;
  label chincpue='CHINOOK CPUE' sockcpue='SOCKEYE CPUE' chumcpue='CHUM CPUE'
       cohocpue='COHO CPUE';
  run;

title2 'TIDAL CPUE SUMMED BY DAY';
proc print noobs label data=histday;
  var date chincpue sockcpue chumcpue cohocpue;
  run;

*END HISTORIC BETHEL TESTFISH DATA PROCESSING SECTION;

*FOR EFFORT CALCULATION;
*DELETE STATION 2 DRIFTS WITH SHALLOW 5-3/8 INCH MESH ON AND AFTER 29 JUNE;
*DELETE STATION 2 DRIFTS WITH SHALLOW 4 INCH MESH ON AND AFTER 08 JULY;
data tfsum2; set tfsummar;
  if date ge '29JUN94'D then do;
    if station eq 2 and panels eq 1 then do;
      if mesh eq 5.375 then delete;
      if date ge '12JUL94'D and mesh eq 4.0 then delete;
      end;
    if station eq 2 or station eq 3 then station=2.5;
    end;
  run;

proc summary data=tfsum2 nway;
  class date tide station mesh;
  var fathhrs;
  output out=effort1 sum=meffort;
  run;

*FINALLY, REARRANGE DATA TO PUT EFFORTS FOR ALL MESHES ON A SINGLE LINE;
proc transpose data=effort1 out=effort2;
  var meffort; id mesh;
  by date tide station;
  run;

*MERGE REPORT PERIOD NUMBER WITH TESTFISH DATA;
```

```
data effort; merge effort2(drop=_name_ in=a) snrwide(keep=date report);
  by date;
  rename _2d75  =effort1;
  rename _4     =effort2;
  rename _5d375 =effort3;
  rename _6d5   =effort4;
  rename _8     =effort5;
  run;


*READ IN AN EXTERNAL FILE WHICH SETS WHICH MESHES WILL BE USED TO ESTIMATE
 CPUE FOR EACH SPECIES, AND WHICH SPECIES CATCHES WILL BE ADJUSTED FOR NET
 SELECTIVITY;
data specmesh;
  infile 'd:\runsasw\spcmsh94.btf' firstobs=17;
  length species $ 8;
  length adjust $ 3;
  input method species usemesh1-usemesh5 adjust;
  run;

*MERGE SPECIES-MESH PAIRING DATA INTO TESTFISH DATA SET;
*DELETE FISH FROM SHALLOW NETS FISHED AT STATION 2 IF A DEEP NET WAS AVAILABLE;
*DELETE FISH WHICH WERE NOT CAUGHT IN MESHES TARGETING THAT SPECIES;

proc sort data=testfish; by method species; run;
proc sort data=specmesh; by method species; run;

data tfsm;
  merge testfish(in=a drop=fathoms drifmins) specmesh;
  by method species;
  if a;
  if mesh = 0 then delete;
run;

data tfsm;
  set tfsm;
  array usemesh{5} usemesh1-usemesh5;
  if date ge '29JUN94'd and station eq 2 and panels eq 1 then do;
     if mesh eq 5.375 then delete;
     if date ge '08JUL94'D and mesh eq 4.0 then delete;
     end;

  if date ge '29JUN94'd and (station eq 2 or station eq 3) then do;
    if spcode eq 5 then do;
     usemesh1 = 0;
     if date ge '12JUL94'D then usemesh2=1; else usemesh2=0;
     usemesh3 = 1;
     usemesh4 = 0;
     usemesh5 = 0;
     end;
    station = 2.5;
    end;
  if usemesh{meshcode}=0 then delete;
run;

*MERGE NET SELECTIVITY CURVE DATA INTO TESTFISH (+SM) DATA SET;
data netselec;
  infile 'd:\runsasw\netsel94.btf' missover firstobs=5;
  length species $8;
  input method @5 species lclassmp 14-17 prob1 21-25 prob2 27-31 prob3 33-37
```

```
                    prob4 39-43 prob5 45-49;
 run;

proc sort data=tfsm; by method species lclassmp; run;
proc sort data=netselec; by method species lclassmp; run;
data tfsmns; merge tfsm(in=b) netselec; by method species lclassmp;
 if b;
 run;

title2 'NET SELECTIVITY ESTIMATES USED TO ADJUST CATCHES';
proc print label noobs data=netselec; run;

*MERGE EFFORT DATA INTO TESTFISH (+SM+NS) DATA SET;
proc sort data=tfsmns; by date tide station mesh; run;
data tfsmnsef; merge tfsmns(in=c) effort; by date tide station; if c;
 array usemesh{5} usemesh1-usemesh5;
 array prob{5} prob1-prob5;
 array effort{5} effort1-effort5;
 *FOR MAJOR SPECIES, ADJUST CATCH (I.E., 1 FISH) FOR NET SELECTIVITY;
 *IF NET SELECTIVITY IS NOT KNOWN FOR THIS FISH, THEN DELETE OBSERVATION;
 *DELETE RECORDS OF DRIFTS THAT WERE MISSED;
 if drift = 0 or station = 8 then delete;
 meanprob=0.7;
 if adjust='N' then adjcatch=1/meanprob;
 else if adjust='Y' then do;
   if prob{meshcode} ne . then adjcatch=1/prob{meshcode};
   else if prob{meshcode} eq . then delete;
   end;
 *SUM EFFORT FOR ALL MESHES TARGETING THIS SPECIES DURING THIS TF PERIOD;
 *IF SPECIES IS ADJUSTED FOR NET SELECTIVITY, THEN DO NOT CONSIDER THOSE
  MESHES FOR WHICH NET SELECTIVITY IS NOT KNOWN FOR THIS FISH;
 *FINALLY, CALCULATE ADJUSTED CPUE FOR EACH FISH;
 sumeff=0;
 do imesh=1 to 5;
   if adjust='Y' then do;
     if prob{imesh} = . then usemesh{imesh}=0;
     end;
   if effort{imesh}=. then effort{imesh}=0;
   sumeff=sumeff+effort{imesh}*usemesh{imesh};
   end;
 adjcpue=adjcatch/sumeff;
 format date date7. startout time5.
       effort1-effort5 sumeff adjcatch 5.2;
 run;

/*
*OPTIONAL PRINTOUT FOLLOWS: SHOWS INTERMEDIARY CALCULATIONS ON TESTFISH DATA;
data print; set tfsmnsef(obs=100);
title2 'PART OF DATA SET WORK.TFSMNSEF';
title3 'ONE LINE PER FISH, EACH LINE ALSO HAS INFORMATION ON NET SELECTIVITY';
title4 'CURVE PARAMETERS AND EFFORT FOR EACH MESH DRIFTED DURING THAT PERIOD';
 run;
 proc print data=print;
 var REPORT date tide drift startout station mesh species spcode lclassmp
     adjcatch usemesh1-usemesh5 effort1-effort5 sumeff adjcpue;
 run;
*/

*SUM ADJUSTED CPUE FOR EACH SPECIES DURING EACH TESTFISH PERIOD;
proc summary data=tfsmnsef nway;
```

```
 class REPORT date tide station spcode;
 var adjcpue adjcatch; id startout species;
 output out=spcpue sum=spcpue spcatch;
 run;

*TRANSPOSE BY ALL BUT SPECIES (CODE), CREATING A SEPARATE VARIABLE FOR CPUE OF
 EACH SPECIES;
proc transpose data=spcpue out=spcpwide;
 by REPORT date tide station;
 var spcpue;
 id spcode;
 run;

proc summary data=spcpue nway;
 class REPORT date tide station;
 var spcatch;
 output out=catch sum(spcatch)=adjcatch;
 run;

*SUM CPUE'S FOR ALL SPECIES DURING A GIVEN TESTFISH PERIOD;
data spcpwide; merge spcpwide catch; by REPORT date tide station;
 array cpue{9} _1-_9;
 sumcpue=0;
 do i=1 to 9;
   if cpue{i} = . then cpue{i} = 0;
   sumcpue= sumcpue + cpue{i};
   end;
 format _1-_9 adjcatch sumcpue 6.2;
 run;

*CALCULATE DAILY CPUE BY SPECIES AND A TOTAL FOR ALL SPECIES;
*REPRESENT CPUE AS CATCH PER 100 FATHOM HOURS;
title2 'CPUE (expressed as catch per 100 fath-hrs) BY STATION AND DATE';

data spnewcp; set spcpwide;
 lchincp=_1*100; sockcp=_2*100; cohocp=_3*100; pinkcp=_4*100;
 chumcp=_5*100; whitecp=_6*100; ciscp=_7*100; schincp=_8*100;
 othcp=_9*100; scpue=sumcpue*100;
run;
proc summary data = spnewcp nway;
 class station date;
 var lchincp sockcp cohocp pinkcp chumcp whitecp ciscp schincp
  othcp scpue;
 output out = mndaycp
   mean = ;
run;
data mndaycp;
 set mndaycp;
 label lchincp='LCHINOOK' sockcp='SOCKEYE' cohocp='COHO' pinkcp='PINK'
 chumcp='CHUM' whitecp='WHITE' ciscp='CISCO' schincp='SCHINOOK'
 othcp='OTHER' scpue='Total CPUE';
 format lchincp sockcp cohocp pinkcp chumcp whitecp ciscp
   schincp othcp scpue 6.1;
run;
proc print noobs label data = mndaycp;
 var date station lchincp schincp sockcp chumcp cohocp pinkcp
     whitecp ciscp othcp scpue;
run;

*SUM CPUE, FOR EACH SPECIES AND FOR ALL SPECIES, ACROSS ALL TIDES
```

```
 WITHIN EACH REPORTING PERIOD;
*CALCULATE THE AVERAGE TOTAL (ALL SPECIES) CPUE IN EACH REPORT PERIOD;
*COUNT THE NUMBER OF TESTFISH PERIODS IN EACH REPORT PERIOD;
proc summary data=spcpwide nway;
  class REPORT station;
  var _1-_9 sumcpue;
  output out=rncpue sum=rnspcp1-rnspcp9 rnsmcp
              mean(sumcpue)=rnmncp  n=n;
  run;

*MERGE THE ORIGINAL DATA SET WITH THE SUMMARIZED DATA SET, THEN CALCULATE:
 ESTIMATED PROPORTION OF EACH SPECIES DURING EACH TESTFISH PERIOD,
 ESTIMATED PROPORTION OF EACH SPECIES DURING EACH REPORT PERIOD,
 AND A WEIGHTED SQUARED DEVIATION OF THE TESTFISH PERIOD PROPORTION FROM
 THE REPORT PERIOD PROPORTION;
proc sort data=spcpwide; by report station; run;
data varcalc;
  merge spcpwide rncpue;
  by REPORT station;
  array cpue{9} _1-_9;
  array rnspcp{9} rnspcp1-rnspcp9;
  array phatpr{9} phatpr1-phatpr9;
  array phatrp{9} phatrp1-phatrp9;
  array sqrdev{9} sqrdev1-sqrdev9;
  weight=sumcpue/rnmncp;
  if sumcpue = 0 then put 'NOTE: NO FISH CAUGHT ON TIDE  ' tide ',  ' date;
  else do i=1 to 9;
     phatpr{i}=cpue{i}/sumcpue;
     phatrp{i}=rnspcp{i}/rnsmcp;
     sqrdev{i}=(weight**2)*(phatpr{i}-phatrp{i})**2;
     end;
  label phatpr1='LCHINOOK' phatpr2='SOCKEYE' phatpr3='COHO' phatpr4='PINK'
  phatpr5='CHUM' phatpr6='WHITE' phatpr7='CISCO' phatpr8='SCHINOOK'
  phatpr9='OTHER';
  format phatpr1-phatpr9 4.3 adjcatch 5.1;
  run;

*PRINT SPECIES PROPORTIONS BY TIDE;
proc sort data=varcalc out=print; by station REPORT date tide; run;
title2 'ESTIMATED SPECIES PROPORTIONS AND TOTAL ADJUSTED CATCH, BY TIDE AND STATION';
run;
proc print noobs label data=print;
  var station REPORT date tide adjcatch
     phatpr1 phatpr8 phatpr2 phatpr5 phatpr4 phatpr3 phatpr6 phatpr7 phatpr9;
  run;


*SUM THE SQUARED DEVIATIONS BY REPORT PERIOD;
proc summary data=varcalc nway;
  class REPORT station;
  var sqrdev1-sqrdev9 adjcatch;
  id phatrp1-phatrp9 n date;
  output out=varprop sum=smsqdv1-smsqdv9 adjcatch;
  run;

*AND CALCULATE THE VARIANCE OF THE REPORT PERIOD PROPORTION (COCHRAN 1977);
data varprop; set varprop (drop = _type_ _freq_);
  array varprp{9} varprp1-varprp9;
  array smsqdv{9} smsqdv1-smsqdv9;
  array stdprp{9} stdprp1-stdprp9;
```

```
array cvprop{9} cvprop1-cvprop9;
  array phatrp{9} phatrp1-phatrp9;
  do i = 1 to 9;
    varprp{i}=smsqdv{i}/(n*(n-1));
    stdprp{i}=sqrt(varprp{i});
    if phatrp{i} gt 0 then cvprop{i}=stdprp{i}/phatrp{i};
    else cvprop{i}=0;
    end;
  format phatrp1-phatrp9 5.3 stdprp1-stdprp9 3.2 adjcatch 5.1;
  label phatrp1='LCHINOOK' phatrp2='SOCKEYE' phatrp3='COHO' phatrp4='PINK'
  phatrp5='CHUM' phatrp6='WHITE' phatrp7='CISCO' phatrp8='SCHINOOK'
  phatrp9='OTHER';
  label stdprp1='se' stdprp2='se' stdprp3='se' stdprp4='se'
  stdprp5='se' stdprp6='se' stdprp7='se' stdprp8='se' stdprp9='se';
  run;


proc sort data=varprop out=print; by station; run;
title2 'ESTIMATED SPECIES PROPORTIONS AND STANDARD ERRORS, BY REPORT PERIOD';
proc print label data=print noobs; by station;
  var station REPORT date adjcatch phatrp1 stdprp1 phatrp8 stdprp8 phatrp2 stdprp2
                    phatrp5 stdprp5 phatrp4 stdprp4 phatrp3 stdprp3
                    phatrp6 stdprp6 phatrp7 stdprp7 phatrp9 stdprp9;
  run;


*NOW MERGE DATA SET CONTAINING COUNTS WITH DATA SET CONTAINING PROPORTIONS,
 AND CALCULATE SPECIES PASSAGE ESTIMATES AND THEIR ESTIMATED VARIANCE;*


*GENERATE DAILY CUMULATIVE PASSAGE NUMBERS;
proc sort data=snrcnts; by report station; run;
data daystpsg;
  merge snrcnts varprop(in=a drop=date);  by REPORT station;
  if a;
  array phatrp{9} phatrp1-phatrp9;
  array dspsg{9} dspsg1-dspsg9;
  do i=1 to 9;
    dspsg{i}=phatrp{i}*psg;
    end;
  format dspsg1-dspsg9 8.;
  run;

proc summary data=daystpsg nway;
  class report date;
  var dspsg1-dspsg9;
  output out=daypasg sum=;
  run;

title2 'DAILY PASSAGE ESTIMATES'; run;
proc print data=daypasg label noobs;
  label dspsg1='LCHINOOK' dspsg2='SOCKEYE' dspsg3='COHO' dspsg4='PINK' dspsg5='CHUM'
     dspsg6='WHITE' dspsg7='CISCO' dspsg8='SCHINOOK' dspsg9='OTHER';
  var report date dspsg1-dspsg9;
  run;

data dpcum; set daypasg;
  array dspsg{9} dspsg1-dspsg9;
  array cp{9} cp1-cp9;
  retain cp 0;
```

```
do i = 1 to 9;
   cp{i}=cp{i} + dspsg{i};
   end;
 run;

*CALCULATE VARIANCE BY REPORT PERIOD;
data pasgvar;
 merge reptcnts varprop(in=a);
 by REPORT station;
 if a;
 array phatrp{9} phatrp1-phatrp9;
 array varprp{9} varprp1-varprp9;
 array rptpsg{9} rptpsg1-rptpsg9;
 array varrpt{9} varrpt1-varrpt9;
 array stdrpt{9} stdrpt1-stdrpt9;
 do i=1 to 9;
   rptpsg{i}=phatrp{i}*psg;
   varrpt{i}=(psg**2)*varprp{i};
   stdrpt{i}=sqrt(varrpt{i});
   end;
 format psg rptpsg1-rptpsg9 8. varprp1-varprp9
       varrpt1-varrpt9 e9. phatrp1-phatrp9 5.3;
 label REPORT='REPORTING PERIOD';
 label rptpsg1='LCHINOOK' rptpsg2='SOCKEYE' rptpsg3='COHO' rptpsg4='PINK' rptpsg5='CHUM'
    rptpsg6='WHITE' rptpsg7='CISCO' rptpsg8='SCHINOOK' rptpsg9='OTHER';
 run;

proc summary data=pasgvar;
 var rptpsg1-rptpsg9 varrpt1-varrpt9 date;
 output out=cumstat sum(rptpsg1-rptpsg9)=psg1-psg9
               sum(varrpt1-varrpt9)=varpsg1-varpsg9
               max(date)=;
 run;

data cumstat; set cumstat (drop=_type_);
 rename _freq_=nreports;
 array psg{9} psg1-psg9;
 array varpsg{9} varpsg1-varpsg9;
 array stdpsg{9} stdpsg1-stdpsg9;
 array cvar{9} cvar1-cvar9;
 do i = 1 to 9;
   stdpsg{i}=sqrt(varpsg{i});
   if psg{i}=0 then cvar{i}=0;
   else cvar{i}=100*stdpsg{i}/psg{i};
   end;
 run;

data std; set cumstat (keep=stdpsg1-stdpsg9);
 rename stdpsg1=cp1; rename stdpsg2=cp2; rename stdpsg3=cp3; rename stdpsg4=cp4;
 rename stdpsg5=cp5; rename stdpsg6=cp6; rename stdpsg7=cp7; rename stdpsg8=cp8;
 rename stdpsg9=cp9; type = 'STD ERROR';
 run;

data cvar; set cumstat (keep=cvar1-cvar9);
 rename cvar1=cp1; rename cvar2=cp2; rename cvar3=cp3; rename cvar4=cp4;
 rename cvar5=cp5; rename cvar6=cp6; rename cvar7=cp7; rename cvar8=cp8; rename cvar9=cp9;
 type = 'C.V. (%)';
 run;

data missing;
```

```
 cvar1=.; cvar2=.; cvar3=.; cvar4=.; cvar5=.; cvar6=.; cvar7=.; cvar8=.; cvar9=.;
 run;

data print; set dpcum missing std cvar;
 format cp1-cp9 7.;
 label cp1='LCHINOOK' cp2='SOCKEYE' cp3='COHO' cp4='PINK'
      cp5='CHUM'   cp6='WHITE'  cp7='CISCO' cp8='SCHINOOK' cp9='OTHER';
 label type='.';
 run;

title2 'CUMULATIVE PASSAGE BY DAY, DERIVED FROM 3+ DAY REPORTING PERIOD PROPORTIONS';
proc print data=print label noobs;
 var type REPORT date cp1 cp8 cp2 cp5 cp4 cp3 cp6 cp7 cp9;
 run;
```

Appendix A.2 Input data file SPCMSH94.BTF called by BTF94.SAS to set mesh sizes to be used for each species in adjusting catch by net selectivity coefficients.

SPCMSH94.BTF: sets which meshes will be used (by BTF94.SAS) to estimate CPUE for each species and also sets which species' catches will be adjusted for net selectivity.

A "1" in the column for a given mesh indicates that fish of that species caught in that mesh will be used to calculate relative CPUE and in turn allocate sonar counts to species.

A "Y" in the ADJUST column will cause the program to adjust catches of that species for net selectivity, a "N" will cause the program to not adjust.

METHOD: 1=DRIFT 2=SET

| | | MESH SIZE | | | | | |
|---|---|---|---|---|---|---|---|
| METHOD | SPECIES | 2.75 | 4.0 | 5.375 | 6.5 | 8.0 | ADJUST? |
| 1 | LCHINOOK | 0 | 0 | 1 | 1 | 1 | Y |
| 1 | SOCKEYE | 0 | 1 | 1 | 1 | 1 | Y |
| 1 | COHO | 0 | 1 | 1 | 1 | 0 | Y |
| 1 | PINK | 0 | 1 | 1 | 0 | 0 | N |
| 1 | CHUM | 0 | 1 | 1 | 1 | 1 | Y |
| 1 | WHITE | 1 | 1 | 1 | 0 | 0 | Y |
| 1 | CISCO | 1 | 1 | 0 | 0 | 0 | Y |
| 1 | OTHER | 0 | 1 | 1 | 1 | 0 | N |
| 1 | SCHINOOK | 0 | 1 | 1 | 1 | 1 | Y |
| 1 | NONE | 0 | 0 | 0 | 0 | 0 | N |
| 2 | LCHINOOK | 0 | 0 | 0 | 1 | 0 | N |
| 2 | SOCKEYE | 0 | 0 | 1 | 0 | 0 | N |
| 2 | COHO | 0 | 0 | 1 | 0 | 0 | N |
| 2 | PINK | O | 1 | 0 | 0 | 0 | N |
| 2 | CHUM | 0 | 0 | 1 | 0 | 0 | N |
| 2 | WHITE | 0 | 1 | 0 | 0 | 0 | N |
| 2 | CISCO | 1 | 0 | 0 | 0 | 0 | N |
| 2 | OTHER | 0 | 1 | 1 | 0 | 0 | N |
| 2 | SCHINOOK | 0 | 1 | 0 | 0 | 0 | N |
| 2 | NONE | 0 | 0 | 0 | 0 | 0 | N |

Appendix A.3 Input data file NETSEL94.BTF called by BTF94.SAS to set net selectivity coefficients for species-mesh combinations. The '1' or '2' in column one designates drift or set gillnets, respectively.

| METHOD | SPECIES | LENGTH | 2.75 | 4.0 | 5.4 | 6.5 | 8.0 |
|---|---|---|---|---|---|---|---|
| 1 | COHO | 400 | | 0.999 | | | |
| 1 | COHO | 440 | | 0.884 | | | |
| 1 | COHO | 480 | | 0.804 | 0.796 | | |
| 1 | COHO | 520 | | 0.469 | 0.977 | | |
| 1 | COHO | 560 | | 0.297 | 0.981 | 0.549 | |
| 1 | COHO | 600 | | 0.195 | 0.681 | 0.892 | |
| 1 | COHO | 640 | | 0.283 | 0.993 | | |
| 1 | CHUM | 440 | | 0.647 | 0.277 | | |
| 1 | CHUM | 480 | | 0.695 | 0.790 | | |
| 1 | CHUM | 520 | | 0.161 | 1.000 | 0.163 | |
| 1 | CHUM | 560 | | 0.773 | 0.804 | | |
| 1 | CHUM | 600 | | 0.390 | 0.950 | | |
| 1 | CHUM | 640 | | 0.319 | 0.990 | 0.286 | |
| 1 | CHUM | 680 | | 0.245 | 0.847 | 0.472 | |
| 1 | SCHINOOK | 450 | | 0.676 | 0.759 | | |
| 1 | SCHINOOK | 550 | | 0.237 | 0.987 | 0.812 | |
| 1 | SCHINOOK | 650 | | 0.316 | 0.384 | 0.999 | 0.339 |
| 1 | LCHINOOK | 650 | | 0.316 | 0.384 | 0.999 | 0.339 |
| 1 | LCHINOOK | 750 | | 0.143 | 0.317 | 0.799 | 0.963 |
| 1 | LCHINOOK | 850 | | 0.292 | 0.324 | 0.846 | 0.985 |
| 1 | LCHINOOK | 950 | | 0.281 | 0.659 | 0.642 | 0.902 |
| 1 | LCHINOOK | 1050 | | 0.325 | 0.355 | 0.781 | |
| 1 | SOCKEYE | 440 | | 0.784 | 0.291 | | |
| 1 | SOCKEYE | 480 | | 0.787 | 0.394 | | |
| 1 | SOCKEYE | 520 | | 0.349 | 0.988 | | |
| 1 | SOCKEYE | 560 | | 0.294 | 0.945 | 0.200 | |
| 1 | SOCKEYE | 600 | | 0.342 | 0.646 | 0.895 | |
| 1 | SOCKEYE | 640 | | 0.466 | 0.443 | 0.999 | 0.241 |
| 1 | SOCKEYE | 680 | | 0.936 | 0.936 | 0.780 | |
| 1 | WHITE | 320 | 0.900 | 0.281 | | | |
| 1 | WHITE | 360 | 0.600 | 0.721 | | | |
| 1 | WHITE | 400 | 0.310 | 0.994 | | | |
| 1 | WHITE | 440 | 0.300 | 0.869 | | | |
| 1 | WHITE | 480 | 0.300 | 0.691 | 0.414 | | |
| 1 | WHITE | 520 | | 0.948 | | | |
| 1 | CISCO | 280 | 0.486 | | | | |
| 1 | CISCO | 320 | 0.953 | | | | |
| 1 | CISCO | 360 | 0.894 | | | | |
| 1 | CISCO | 400 | 0.480 | 0.500 | | | |
| 1 | CISCO | 440 | 0.790 | | | | |
| 2 | COHO | 600 | | | | | |
| 2 | COHO | 640 | | | | | |
| 2 | CHUM | 440 | | | | | |
| 2 | CHUM | 480 | | | | | |
| 2 | CHUM | 520 | | | | | |
| 2 | CHUM | 560 | | | | | |
| 2 | CHUM | 600 | | | | | |
| 2 | CHUM | 640 | | | | | |
| 2 | CHUM | 680 | | | | | |
| 2 | SCHINOOK | 450 | | | | | |
| 2 | SCHINOOK | 550 | | | | | |
| 2 | SCHINOOK | 650 | | | | | |
| 2 | LCHINOOK | 650 | | | | | |
| 2 | LCHINOOK | 750 | | | | | |
| 2 | LCHINOOK | 850 | | | | | |
| 2 | LCHINOOK | 950 | | | | | |
| 2 | LCHINOOK | 1050 | | | | | |
| 2 | SOCKEYE | 440 | | | | | |
| 2 | SOCKEYE | 480 | | | | | |
| 2 | SOCKEYE | 520 | | | | | |
| 2 | SOCKEYE | 560 | | | | | |
| 2 | SOCKEYE | 600 | | | | | |
| 2 | SOCKEYE | 640 | | | | | |
| 2 | SOCKEYE | 680 | | | | | |
| 2 | WHITE | 320 | | | | | |
| 2 | WHITE | 360 | | | | | |
| 2 | WHITE | 400 | | | | | |
| 2 | WHITE | 440 | | | | | |
| 2 | WHITE | 480 | | | | | |
| 2 | WHITE | 520 | | | | | |